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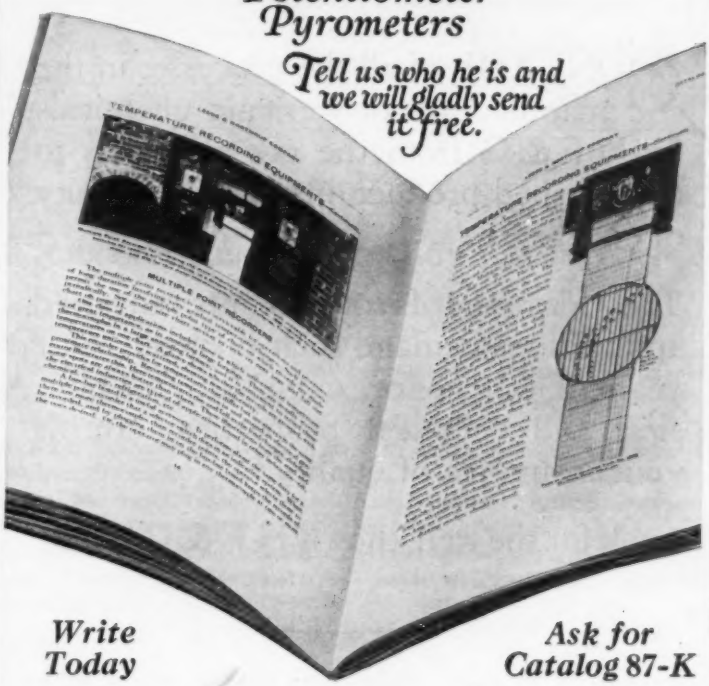

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ORIGINAL PAPERS

CHARACTERISTICS OF PYROMETRIC CONES[1]

BY C. O. FAIRCHILD[2] AND M. F. PETERS[3]

ABSTRACT

For the first time the characteristics of pyrometer cones have been determined under definite and reproducible conditions of heating. The temperatures of the "end points" of a complete set of cones together with their bending intervals were measured at carefully controlled rates of heating in clean air and in various kiln gases. Heated at 20°C per hour in furnace gases free from SO_2, the end points of cones 015 to 01 are somewhat higher than those observed when the cones were heated in clean air. Cones 022 to 016 and 1 to 42 were acted upon only slightly by kiln gases free from SO_2. There is more significance in the demonstration of the utility of measuring the end points of the cones under accurately controlled and known conditions of heating than in the numerical results obtained.

Introduction

Pyrometric cones are the most widely used of all devices for the control of the heat treatment of clay products and therefore engage the interest of all ceramists. The fullest usefulness of these devices depends primarily upon reproducible quantitative data obtained under standardized conditions approximating those met with in ceramic practice. To procure such data was the aim of the investigation here described.

[1] Published with permission of the Director, Bureau of Standards, Department of Commerce. Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Atlanta, Ga., Feb., 1926. Revised and received by Editor, July 24, 1926.

[2] Physicist, Chief of Pyrometry Section.

[3] Associate Physicist, Pyrometry Section.

A few years ago some of us believed that pyrometers would ultimately displace cones for the control of kilns. This position was taken not without reason but without a sufficient appreciation of the problems in ceramic firing.

The advice of successful ceramists has for years been and still is to use pyrometers not occasionally but constantly. in every kiln and fire, but unless the behavior of a cone in a kiln can be fairly accurately associated with temperature it will be very difficult to correlate its behavior with the indications of a pyrometer and consequently it will be impossible to make full use of both.

A committee of ceramists was asked to coöperate and advise concerning ceramic practice in its relation to the use of cones. This Committee consisted of P. H. Bates, Chairman, representing the AMERICAN CERAMIC SOCIETY; Edward Orton, Jr., proprietor of the Standard Pyrometric Cone Co.; James Turner, representing the United States Potters Association; Walter S. Mayer, vice president, Mayer China Co., and manufacturer of "Mayer" cones; M. C. Booze, representing the Refractories Manufacturers Association; and R. F. Geller, representing the Ceramic Division of the Bureau.

The Committee met on May 5, 1924, and made recommendations concerning rates of firing and methods of mounting cones. The method of studying the effects of kiln atmosphere was approved. The Committee advised limiting the present studies to cones made by the Standard Pyrometric Cone Company.

This investigation was directed to accomplish the following:

1. Accurate determinations of the "end points" of cones, and the influence of firing rate and furnace atmosphere upon them.
2. Establishment of standard methods for testing cones, thereby indicating methods for testing the refractoriness of materials.
3. Development of laboratory methods which will produce results applicable to plant conditions and industrial practice.
4. Promotion of the practice of pyrometry in ceramic engineering.
5. Decision as to whether cones should be used in laboratory tests of clay products.

Historical Review

Credit for the invention of the fusible cone has been given to Lauth and Voght,[1] but their invention was apparently not followed by widespread industrial use. In 1886, Seger published[2] the descriptions

[1] *Bull. Soc. Chim.*, **46**, p. 786 (1886); cf. Burgess and Le Chatelier, "High Temperature Measurements," p. 368, 1912.

[2] Collected Writings, I, p. 224. Gesammelte Schriften, p. 178.

and compositions of cones 1 to 36, making no reference to the work of Lauth and Voght, and industrial application immediately followed.

Pyrometry was in its infancy in 1886 and there was no satisfactory means for measuring kiln temperatures at that time. This condition was recognized by Seger and he proceeded in an endeavor to invent a reliable pyrometric device. His purpose is set forth in the following quotation:

> If now, in order to follow a proposition made by Dr. Heintz of Saarau, we disregard the determination of temperatures according to the ordinary conception of degrees, for the purposes of the ceramic industries, we can put in its place a series of tetrahedrons made out of glazes which melt down, one after the other, and infer the temperature attained from the number of tetrahedrons which have melted or express the attainment of a certain temperature in the kiln by the melting of a definite glaze.

While it may appear from this quotation that Seger proposed to set up a temperature scale expressed in "cone numbers" for use exclusively in the ceramic industries it is evident that he believed each cone possessed a definite melting point and that each cone number corresponded to a definite temperature. Believing this to be the case, he wrote as follows:

> I am of the opinion that a scale of refractoriness for the testing of fire clays alone is not good in principle, but that one scale should be made applicable to all industries; for if every industry will adopt its own scale for the measurement of temperatures others will naturally be led to measure fire clays with their standards, and great confusion and errors would be the result.

The original cone-temperature table was published about 1900. This table included cones from 01 to 022 devised by Cramer and Hecht.[1] It was soon learned[2] that the cones when used in large, slow heating kilns fused at lower temperatures than those given in the table.

The effect of furnace gases upon the "end points" was not generally noticed, although, in 1900, Gorton[3] described the action of kiln gases upon cones containing iron oxide.

Ceramists were at this time inclined toward overconfidence in the temperatures indicated by pyrometers, although experimenters in other fields were finding that pyrometer errors were of the same magnitude as the differences apparent between cones and pyrometers. Geijsbeek[4] criticized Orton[5] and Purdy[6] for doubting the accuracy

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[1] *Tonind. Zeit.*, 1892, 1895.
[2] *Trans. Amer. Ceram. Soc.*, **1**, 23 (1899).
[3] *Ibid.*, **2**, 60 (1900).
[4] *Ibid.*, **6**, 94 (1904).
[5] *Ibid.*, **5**, 305 (1903).
[6] *Ibid.*, **5**, 160 (1903).

of their temperature measurements, but only a few years previously the temperature scale had been changed about 15° at 1100°C.

Purdy,[1] in studying the behavior of stoneware glazes fired on a time-temperature schedule "as closely as possible, using a thermocouple pyrometer" and made the significant statement that:

> While these glazes thus tabulated fused considerably under cone 2, and would give good glassy glazes at cone 2 or lower when fired in as short a period of time as this test, they would require cones 5–7 in the longer firings of the regular stoneware operations.

In 1907, Hofmann[2] determined the fusion temperatures of cones 1 to 20 in an iridium tube furnace, heated at a rate of approximately 300°C per hour and open to air. Two years later he extended the investigation to cone 35 by the same method and, in 1911, he published the results of temperature measurements of the "end points" of a few cones heated in industrial kilns. These later tests covered only cones 2 to 17 in a few kilns heated according to the regular schedules, but left no doubt that the cones came down 40 to 100°C below the temperatures observed in the iridium tube furnace. The results were considered merely as indicative of unavoidable differences and no attempt was made to establish the exact conditions under which the cones were heated in the industrial kilns.

Rieke[3] studied cones 022 to 15 including the new "a" series developed by Simonis[4] and concluded: (1) fusion points are dependent on the rate of heating, a most important factor; (2) cones melt at lower temperatures when heated slowly except certain ones which are in a way devitrified especially on the surface; (3) from cone 1 up slow heating lowers the melting points sometimes as much as 100°C; (4) the melting temperatures cannot be determined once for all. Cones can be used for temperature measurements only when the temperatures "have been ascertained for definite, exactly reproducible conditions"; (5) the usefulness of cones depends mainly upon the fact that they consist of silicate mixtures *more or less resembling ceramic compositions and consequently are similarly influenced by varying conditions.* [The italics are ours.]

Geijsbeek[5] published in 1912 a résumé of the previous work and stated conclusions similar to Rieke's.

Orton stated in the discussion of Geijsbeek's paper:

> It is generally conceded that it is unfortunate that Seger in first introducing the cones brought in the idea of using them for measuring temperatures, and there are grounds for believing that Dr. Seger recognized this himself shortly after it had been done.

[1] *Trans. Amer. Ceram. Soc.* **1**, 23 (1899).
[2] *Tonind. Zeit.*, **31**, 1366 (1907).
[3] *Sprechsaal*, **44**, 726 (1911).
[4] *Ibid.*, **41**, (1908); *Tonind. Zeit.* (1908).
[5] *Trans. Amer. Ceram. Soc.*, **14**, 849 (1912).

Bleininger and Brown,[1] in 1911, while discussing the viscosity of clays at high temperatures, wrote:

> The saving feature of the Seger cones is the fact that, ... they are (always) subject to practically the same gravitational pull, and hence, bend over as soon as a certain degree of fluidity has been attained.

Sosman[2] appears to be the first to apply the laws of physical chemistry to a study of pyrometric cones. The influence of eutectics and compounds formed during vitrification and fusion, on the behavior of cones, was emphasized by this author. He also pointed out the causes for the slow fusion of cones and agreed with others that this characteristic contributes to their usefulness as "indicators of heat effects and as such they are very efficient tests for the control of an industrial process."

Brown and Murray[3] observed that:

> It is impossible to work out general rules governing the time temperature relations because certain properties of the clays, such as viscosity at kiln temperatures, vary widely.

Stover,[4] in a paper on "Pottery Firing by Pyrometry" recommended the use of all available means for control including pyrometric cones.

In 1918, Fieldner, Hall, and Feild[5] investigated the cone method of testing the fusibility of coal ash. They gave particular attention to the effects of reducing atmospheres upon cones containing iron and gave an extensive bibliography including the physical chemistry of silicates.

The first contribution to studies of silicate reactions at high temperatures by physico-chemical methods is that of Day and Shepherd[6] on "The Lime-Silica Series of Minerals." They point out the failure of the cone method of determining the melting point of a eutectic mixture or a compound.

Day and Sosman[7] who determined the melting points of a great many minerals, wrote as follows concerning melting phenomena:

> The so-called melting interval of slow-melting compounds (quartz, albite, orthoclase) should be carefully distinguished from the "melting interval" of mixtures (lime-soda

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[1] "Testing of Clay Refractories," Bur. of Stand., *Tech. Paper*, No. 7 (1912).

[2] "The Physical Chemistry of Seger Cones," *Trans. Amer. Ceram. Soc.*, **15**, 482 (1913).

[3] "Function of Time in the Vitrification of Clays," *Trans. Amer. Ceram. Soc.*, **15**, 193 (1913).

[4] *Trans. Amer. Ceram. Soc.*, **15**, 364 (1913).

[5] Bur. Mines, *Bull.*, No. 6., 129 (1918).

[6] *Amer. Jour. Sci.*, **27**, 265 (1906).

[7] *Amer. Jour. Sci.*, **31**, 341 (1911).

feldspars, impure natural minerals). The former melt and become amorphous very slowly, but their melting interval is an interval of *time*, whereas the melting interval of mixtures is an interval of *temperature*. The pure soda feldspar (albite), if held at a temperature slightly above its melting point for a sufficient length of time, will melt completely; the mixture, on the other hand, if held at a temperature within its melting interval, will melt in part, come to equilibrium, and remain indefinitely part crystalline and part liquid.

Limitations of Present Work

In the complete series of cones from 022 to 42, sixty in all, the compositions of forty-eight are relatively complex, some of them containing as many as five minerals and a prepared glass. Eleven of the series are made from varying proportions of silica and alumina, and the last cone, No. 42, consists of alumina alone. With the exception of the last-named and No. 35, which is pure kaolin, none of the entire series is intentionally made as a definite chemical compound or a eutectic mixture.

It is apparent, therefore, that the behavior of a cone during its heat treatment depends, in general, upon a complex array of factors very few of which can be separately or definitely evaluated. The principal properties and actions of cones may be determined while the physical and chemical transformations within each cone in a rising fire may properly remain for a later study.

The compositions of all the cones, in terms of the raw materials used by the manufacturer, have been furnished the Bureau of Standards in confidence by the maker. This information has made it possible to account for variations in properties from one cone to the next and to fit the experiments to the composition.

Brief Description of Behavior of Cones and Factors Involved

The factors which control the actions of cones during their heat treatment may be divided into two classes, *viz.*, (*a*) those controllable to a large extent by the maker, and (*b*) those controlled to a greater or less degree by the user. The first class includes (1) size and shape, (2) fineness of particles, (3) intimacy of mixture, (4) porosity and homogeneity, (5) chemical and mineralogical composition including impurities, (6) physico-chemical composition of materials and particles including whether they are crystalline, colloidal, amorphous or glassy, and whether water of crystallization, dissolved or adsorbed gases, etc., are present, and (7) unknown factors controlled by fixed methods of making. Those in the second class are: (1) mounting and position, (2) oxidation of organic binder, (3) release of H_2O and CO_2, (4) rate of firing, (5) furnace atmosphere, (6) unknown factors controlled by standardized practice.

All these factors may be described differently from the point of view of what takes place within the cone during firing, as follows:

(1) drying and shrinkage, (2) loss of combined H_2O, (3) firing of binder, (4) loss of combined CO_2, (5) reactions with surrounding atmosphere, (6) softening of most fusible constituent, (7) partial loss of volatile constituents such as B_2O_3 and alkalis, (8) chemical reactions and molecular rearrangements, (9) solution of solids in liquid, (10) continued shrinkage, bending, and the effects of surface tension and gravity, (11) crystallization from the liquid constituent, (12) final fusion or melting.

Cause of Bending During the heating of a cone it changes from a porous, heterogeneous, solid material into a viscous or, more properly, a plastic one, never reaching (except during very slow firing) a condition of chemical or physical equilibrium. This change is followed by bending or deformation as the temperature rises. The deformability (plastic or viscous) at any instant is determined not only by the temperature as in the case of a pure simple substance not undergoing molecular changes, but by many changes taking place within the cone, and hence by the length of time elapsing after the cone has reached a certain temperature. It is readily apparent that no simple general law expressing the deformability or consistency as a function of time and temperature can be deduced for cones as can be done for most glasses and many other viscous materials. That there is no general law for fusibility as a function of the content of fluxes was discovered long before "eutectics" were recognized or defined.

However, the maker of cones, by careful trial and control of his manufacturing processes has demonstrated his ability to grade rather uniformly, a series of mineral and chemical mixtures, in such a way that they react in a graded manner to heat treatment. That is, despite the fact that the same eutectic mixture may occur or form in successive cones of a series, care in making them can to some extent mask the influence of the eutectic and produce a truly graded series.

The temperature at which a cone starts to bend may be regarded for some purposes as the temperature at which the viscosity of the glass constitutent has decreased or the amount of glass formed has increased to such an extent that the cone's own weight begins to deform it. The initial deformation may be caused not only by the force of gravity but also by the forces due to shrinkage and vitrification. However, the motion caused by these latter forces is generally slight at temperatures below that at which gravity alone bends the cone. In some cases, to be sure, distortion due to shrinkage may precede what may properly be taken as the true start of bending, and in such cases it is difficult for an observer to decide when bending due to gravity alone commences.

Rate of Bending During the bending, the viscosity depends not only upon the temperature but upon reactions which may occur within the cone. For example, bending may be almost completely halted by a reaction which absorbs or greatly alters the most fusible constituent present. On the other hand the bending may accelerate "abnormally" if the composition of the glass changes. In general, the viscosity decreases and the rate of bending increases if the temperature is rising, but if the temperature remains steady the viscosity normally does not change much. In either case bending will not cease and the cone will finally reach its "end point," which is defined as the temperature at which the tip touches the pat on a level with the base of the cone. This temperature depends, therefore, upon the rate of heating.

Suppose, for example, it is intended to heat the cone at a constant rate. Then at the end of a certain interval of time and at a certain temperature the tip of the cone will reach the pat. If, however, just before this instant the temperature departs from the schedule, the tip will still reach the pat at very nearly the correct time, but the end point will be in error by approximately the departure from the scheduled temperature. If, on the other hand, the rate of heating is changed to a new constant value at a temperature well below the start of bending, the end point will closely approximate the temperature properly assignable to the new rate.

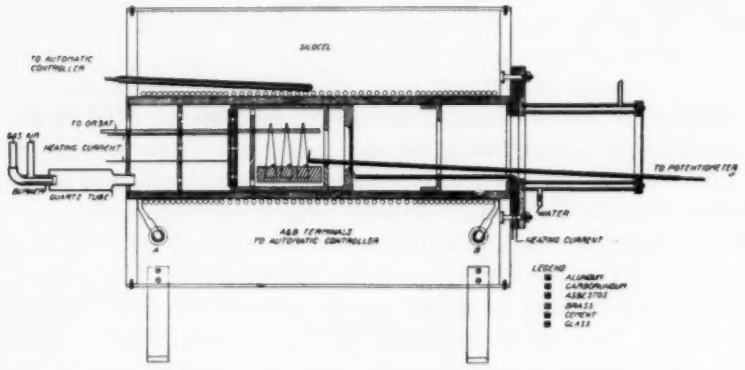

FIG. 1.—Alundum tube furnace with nickel-chromium wire heating-element.

Apparatus and Methods

Furnaces For the experiments with cones fusing below 1200°C, the electric tube furnace shown in longitudinal cross-section in Fig. 1 was constructed. It consists of an alundum tube wound with a heavy (No. 8 gage) nickel-chromium wire heating-

element and diaphragmed with partition walls of Carborundum so as to provide an inner chamber which could be uniformly heated. This chamber is placed somewhat toward the rear of the furnace to offset the loss of heat by radiation through the openings which were necessary for observation of the bending cones. Two of the diaphragms are supplied with small wire heating-elements so that axial temperature gradients can easily be adjusted.

It was not necessary to seal the furnace during tests of the performance of cones in air, but in other tests when various gaseous mixtures were introduced, the back was luted with cement and the front was sealed with a water-cooled glass window. In such tests, the products of combustion from a gas flame entered through the rear wall, traversed three chambers before reaching the inner one and escaped through small openings in the front. In this way the gases attained approximately the temperature of the cones before passing over them.

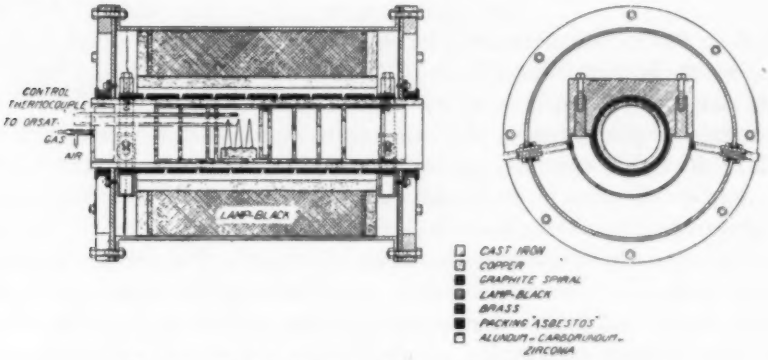

FIG. 2.—Electric furnace with graphite-spiral heater.

The graphite-spiral furnace shown in Fig. 2 was designed to heat the more refractory cones in an oxidizing atmosphere. It consists of a gas-tight iron container holding a graphite spiral between water-cooled copper terminals. A Carborundum tube surrounds the spiral, and within the spiral a tube of Carborundum, alumina, or zirconia[1]

[1] The inner tube and diaphragms made from materials at hand failed at 1840°C slightly above the end point of cone 38. Carborundum tubes and diaphragms were satisfactory up to 1400°C, at which temperature oxidation of the material proceeds fairly rapidly. Tubes made from a mixture of 40% No. 518 Norton cement with 60% white alundum, ground to 60-mesh failed at 1840°C. The zirconia at hand contained considerable silica and did not prove to be very serviceable. An Arsem furnace of old design which does not require description was employed in the determinations of the end points of cones 39 to 42 after learning its performance in checking cones 34 to 38. See Table VI.

is placed, which extends through packing-rings on the end plates. Thus the graphite heater is protected to some extent from the air, and as an additional safeguard against rapid oxidation of the graphite, the space surrounding it is kept filled with illuminating gas. The inner tube is diaphragmed as before, but it was thought impracticable to provide any of the diaphragms with auxiliary heaters capable of withstanding the high temperatures for which the furnace was intended. Therefore, to promote temperature uniformity within the inner chamber and, at the same time, permit a full view of cones mounted in it the diaphragms with a different arrangement of openings, are placed closer together than in the other furnace.

Temperature Measurements

Temperature measurements were made in accordance with the practice described in a publication[1] of the Bureau of Standards. Temperatures given in the present paper are consistent with the "melting points"; zinc, 419.4°C; aluminum (99.85% pure), 659.8°C; gold, 1063°C; palladium, 1553°C.

Below 850°C, temperatures were measured with base metal thermocouples made from No. 22 B. & S. gage chromel and alumel wire. These couples were calibrated by comparison with the primary standard rare metal thermocouples of the Bureau of Standards. Between 850 and 1100° either the base metal couples or optical pyrometers of the disappearing-filament type were employed, and higher temperatures were measured only with the latter type of instrument. During some of the measurements the primary standard optical pyrometer of the Bureau or a modified[2] Leeds and Northrup pyrometer was used.

The Leeds and Northrup pyrometer was calibrated by comparison with the primary standard.

To reduce the errors as far as possible the temperature of each cone in the furnace was measured separately. At lower temperatures a thermocouple mounted in a two-holed porcelain insulating tube was inserted through the front window of the furnace, as shown in Fig. 1, and placed so that its hot junction lay close to the cone whose temperature was to be measured. The bare end of the couple extended beyond the end of the insulating tube about three centimeters and was bent into an arc whose plane was at right angles to the tube so that this curved part of the couple could be brought very close to the cone at the moment the latter reached its end point. Thus the hot junction of the couple is very nearly at the same temperature as the cone.

A new, homogeneous couple was used for each run, or heat, and in the absence of any fumes or gases in the furnace, which would

[1] "Pyrometric Practice," *Tech. Paper*, No. 170, Foote, Fairchild, and Harrison.
[2] Fairchild and Hoover, *Jour. Opt. Soc. Amer. and Rev. of Sci. Inst.*, **7**, 543 (1923).

rapidly attack the couple, there was little likelihood that it could develop appreciable heterogeneity during the few hours of its use.

At higher temperatures an optical pyrometer was sighted through the front of the furnace into a small hole drilled in the cone as shown in Figs. 1, 2, and 3. Measurements were necessary to determine the temperature gradient from the base to the tip of the cone.

The relative positions of the cones in the furnace were altered in repeated runs so that in most cases a cone of a given number was tested in each of the three positions shown. By this means, and by measuring as nearly as possible the temperature of each cone separately, errors due to small temperature gradients were, no doubt, almost negligible. It is believed that the accuracy with which the end points of cones fusing below 1400°C was established was better than 5° and at higher temperatures it was better than 10°.

Measurements of the temperatures within the cone chambers of the furnaces served as checks upon the accuracy with which rates of heating, controlled by separate means, were maintained.

Control of Rate of Heating

In Fig. 1 is shown the thermocouple for controlling the heating rate. It is mounted in a porcelain tube placed close to the heating element on the outside of the furnace tube. By watching closely with a sensitive galvanometer the rate of increase of the e. m. f. of this couple while the furnace was heating, a very slight departure from the schedule could be detected and corrected even before it was apparent within the cone chamber. Account was taken of the difference in temperature between the cone chamber and the control couple and the slight change of this difference as the temperature increased.

The graphite-resistor furnace shown in Fig. 2 was controlled with an accuracy almost equal to that attained with the other, although in this case the control couple was farther from the heater. A rare-metal thermocouple was selected for the high temperatures reached with this furnace and proved to be useful, in the position illustrated, up to 1600°. It was withdrawn from this position to a cooler part of the furnace as the temperature rose above this value and, as before, correction was made for the difference in temperature between it and the cone chamber.

During very long runs at a slow rate of heating, the control couples were connected to an automatic temperature controller made by the Leeds and Northrup Company and modified at the Bureau. Automatic control, however, gave a constant average rate fluctuating somewhat with the operation of the device and for this reason hand control was always used through the temperature range in which the cones in the furnace were bending.

Two rates of heating were used, 20°C and 150°C per hour.

Control of Gas Control of the compositions of the gas used was accomplished with relative ease by careful adjustments of the gas-burners and the employment of pressure regulators in the gas and air lines.

The products from the combustion of Washington illuminating gas do not contain an appreciable percentage of sulphur dioxide, so it was necessary, for study of the action of sulphur dioxide upon the behavior of cones, to add it to the products from the gas flame. It was obtained from a cylinder of liquid SO_2 and the flow of the gas was controlled by connecting the cylinder to the gas burner through a capillary tube. No stop-cock was connected in the SO_2 line, the capillary being selected by trial to give the desired rate of flow.[1] The percentage of SO_2 in the furnace atmosphere was fixed from analyses made during the early part of each run before the furnace had reached a temperature at which partial conversion to SO_3 took place.

Mounting of Cones Great pains was taken to see that the cones were mounted exactly in a prescribed manner. The plaques for use below 1450°C were made of equal parts of kaolin and Carborundum with a small addition of ball clay, and for higher temperatures they were made of ground Alundum and Norton 518 cement. Precaution was taken to make up the pat material with as little water as possible.

After marking each large cone at two inches from the tip it was pushed into the pat to this mark, and the numbered face of the cone was placed against a template so that it made an angle of 82° with the surface of the pat. (See Fig. 3.) Some of the pat material was then used to fill the holes around the base of the cone and the surface of the pat was carefully smoothed. After setting up the cones the pat was dried at 105°C over night. Following this they were placed in one of the furnaces and carefully adjusted so that the marked faces were 8° from vertical, by sighting past the template resting outside the furnace upon a levelled platform.

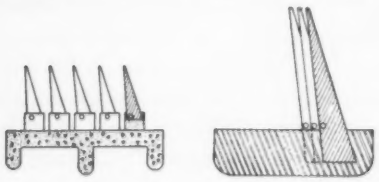

FIG. 3.—Cross-sections of mounted cones.

The small size of cones 23 to 42 made it necessary to mount them in the special manner shown also in Fig. 3, in order that the small holes

[1] The furnace gases were analyzed for SO_2 by absorption in an iodine solution containing iodine per cc equivalent to .0675 cc of SO_2 gas. The percentage of SO_2 was calculated from the volume of furnace gases required to just decolorize 20 cc of this solution in an absorption tube.

bored in their bases would not interfere with the bending. They were mounted with their tips $\frac{3}{4}$ inch above the upper surface of the small bases and the top edges of the holes $\frac{1}{32}$ inch below the surface. The end point of a small cone thus mounted was taken as the temperature at which the tip of the bending cone passed the level of the upper surface of the small base. A few of the most refractory of these small cones do not bend over in fusing but show the first signs of fusion by a rounding of the tip, which is followed by a melting down of the cone into a compact rounded mass. The end point in such a case may properly be taken as the temperature at which the last trace of the original shape disappears into a rounded mass. At this temperature the change in shape is proceeding at a visible rate.

The rates of heating were controlled with particular care during the time the cones were bending, and, depending upon the characteristics of each cone, for a considerable period before bending commenced. In order to avoid the small fluctuations in temperature caused by automatic control, hand control, as stated above, was invariably used for the last few hours of each run, the constant attention of the observer then being required. The 20° rate of heating was maintained during this period to the nearest degree and the faster rate of 150° per hour to 5°, without any sudden irregularities.

Summary of Observations and Tabulated Data

Much of the information obtained has been put in tables of temperatures and cone numbers.

Tables I and II giving the individual observations on the end points of cones 022 to 1, heated in air, are included to show the order in which the work was carried out and the precision which was attained in the temperature measurements. In all the remaining tables of numerical data the individual readings have been averaged in groups and the means have been rounded to the nearest five degrees. The differences in end points obtained under different heating conditions were taken from the unrounded means and are given in the tables without rounding because in many instances the results appeared to be good to a few degrees and rounding tended to obscure some of the relations which it was desirable to point out.

Observations of the colors of the fused cones and the manner of bending, bloating, etc., are summarized in Tables III, V, VIII, and IX.

The gaseous atmospheres employed are indicated in the tables, simply as per cent of CO_2 in the dry gas. The composition of the Washington gas is sufficiently constant for this purpose. From the analysis of this gas the compositions of the products of combustion with excess of air giving 10%, 5%, and 3% CO_2, dry, are found to be approximately:

9% CO_2, 12% H_2O, 7% O_2, 72% N_2, (10% CO_2)
4.5% CO_2, 7% H_2O, 13.5% O_2, 75% N_2, (5% CO_2)
3% CO_2, 5% H_2O, 16% O_2, 76% N_2, (3% CO_2)

Discussion of Results

Cones 022 to 011 Heated in Air

See Tables III and IV. These cones will bend in a normal fashion if they are fired slowly enough in an atmosphere containing sufficient oxygen to allow oxidation of the organic binder before vitrification and the development of a vesicular structure take place. Heating in air at 20° per hour will give good results but it is not necessary to maintain so slow a rate before oxidation or vitrification begins nor after oxidation is complete. The exact limits which assure complete oxidation and the absence of bloating were not determined. Only cones 022 and 021, which begin to vitrify at very low temperatures, require particularly careful firing.

A small amount of bloating of these cones will not affect the end points. They will, in fact, come down at the correct temperatures even if at temperatures a few degrees above the end points, they are bloated to two or three times their original size. In such cases, however, they do not bend normally, because of slight bloating below the end point, and if mounted improperly they will bloat at the base even during the initial bending.

Differences Due to Rate of Heating

Cone 022 contains no clay but is made entirely of a soft glass which is also used for cones 021 to 016 in decreasing percentages. With this series the differences in end points observed at the two rates of heating vary with fair regularity from 18° for cone 022 to 58° for cone 016. That is, the differences increase as the content of glass, or flux, decreases, which is just the reverse of general statements which are found in the literature touching upon this point. The observed regularity is probably due to the fact that there is no volatilization of B_2O_3 nor any reaction between the glass and kaolin at the low temperatures at which these cones fuse.

This relation does not hold for cones 015 to 011 which fuse at higher temperatures and which, moreover, are made of a different glass. In these five cones the relation is apparently upset by some reaction which, in the case of cone 012, proceeds fairly rapidly while the cone is bending, so that, with slow heating the bending interval is 85° and the end point is higher than that observed during rapid heating. Unfortunately, the end point, for slow firing is also higher than that

of the next cone, 011.[1] Again, in cone 011, the reaction proceeds so rapidly that with rapid heating the end point is normally higher than with slow heating, and is even higher than that of cone 010 for rapid heating. The data indicate that under very slow firing cone 020 may also get out of its proper order, and it appears that the fusibility of cones 019 and 018 should be decreased, particularly that of 019.

In general, for this series the temperature intervals of bending are nearly the same for both rates of heating. That is, during bending, the change of consistency or deformability with temperature roughly follows a general law. Of course, this law is not obeyed when reactions occur as in cone 012. It will be noticed that the temperature intervals of bending and the differences of end points for the two rates selected vary in such a way that the starts of bending observed at one rate do not indicate end points for some slower rate. In a few cases the end points observed during slow heating are considerably lower than the "starts" observed during rapid heating, a fact which supports the statement that the "starts" are not precisely determinable.

If a series of cones such as 022 to 017 were all made of an inert material and a stable fusible glass, all the cones could be "brought down" by long-continued heating at a temperature where the glass is appreciably fluid. Such a tendency is indicated in this series as it is now made. At higher temperatures where glass and clay react, such a tendency is, in general, lessened by the reaction.

For such reasons as these, the "load test" for refractory materials has been developed, and in the next section the results of such a test of cones 08, 09, and 010 are given.

Cones 010 to 01 Heated in Air

See Tables IV and V. Each cone of this series is a complex mixture of glass, feldspar, iron oxide, whiting, kaolin, and flint; that is, SiO_2, Al_2O_3, CaO, Fe_2O_3, K_2O, Na_2O, and B_2O_3 with small amounts of impurities.

The "bending intervals" and the "cone intervals" of this series are fairly uniform, but the differences between end points for slow and fast heating can be grouped; cones 010, 09, and 08 are not much affected by the range of heating rates tried, cones 07, 06, 05, and 04 show differences of 10°, and the last three, 03, 02, and 01, differences of 30 to 35°. Thus the differences for the groups are 1–5°, 10°, and

[1] The manufacturer furnished a second lot of cones 012, which do not show these abnormal characteristics. The end point of this cone as it is now being furnished by the manufacturer is 840°C for the 20° rate of heating, and 875°C for the 150° rate. The start of bending is 790° for each rate. Thus the right order of refractoriness is restored, and the reaction previously indicated now manifests itself only in the long bending interval (85°) under rapid heating.

30–35°, a gradation roughly similar to that noted for the most fusible cones. The sudden change from cone 04 to 03 is accounted for by the greater difference in composition between these two cones than between any other successive cones of the series.

These cones contain in smaller proportions the same glass that is present as a large fraction of cone 015 which begins to bend at about 740°C, more than 100° below the start of cone 010. This relatively fusible glass evidently reacts with other constituents at a temperature far below the fusion range of the members of this series, so that the compounds formed are less fusible than one of the constituents originally present. Sosman has mentioned that such reactions are desirable in compounding cones which will not fuse sharply.

A load test applied to these cones should distort them at 740°C. It was tried on cones 08, 09, and 010, which were mounted horizontally in the furnace and loaded near their tips, each with a 25 gm. weight. All three started to bend at 741°, a perfect demonstration of the utility of the load test for fusible constituents of refractory materials.

The cones of this series all fused in a normal fashion in air, and hence no difficulty was met in checking the determinations of the end points to a few degrees.

Cones 1 to 42

See Tables VI and XII. In this group, cones 1, 2, and 3 constitute a single series, 5 to 28 another, 29 and 30 contain only clay, flint, and feldspar, 31 to 34 contain clay and flint, and 36 to 42 contain clay and alumina. Cone 4 is unique. Cone 35 is pure kaolin.

Within experimental accuracy, all cones above No. 1 fused at the same temperature in a gas containing 10% CO_2 as in air, hence the rsults have been averaged and the means arranged in a single table (VI).

The cone intervals are somewhat more uniform than those of the lower series.

The bending intervals of the first three members (1, 2, and 3) of this series are constant from cone to cone for each of the two rates of heating. The differences in end points for fast and slow heating decrease from 35° for cone 1 to 25° for cone 3. This and the fact that there are no reports of these three cones showing a tendency to come down together seem to indicate that the principal fusing ingredient in them is formed during their fusion.

On the other hand the differences in end points (fast minus slow) of cones 4, 5, 6, and 7 increase decidedly from one cone to the next, and Seger, Orton, and Rieke have stated that these few cones show a tendency to come down together.

Discussion of Differences in Fusing Behavior

Cone 9, when heated at 150° per hour, is bending for about 45 minutes and the difference in end points for the two rates has dropped again, which indicates the formation in this cone of a new compound or eutectic mixture melting at about 1250°C.

Cones 10, 11, and 12 show an initial warping which seems to precede ordinary bending, a behavior which may be related to the reaction presumed to take place in cone 9. Sosman has surmised the presence of a eutectic containing lime, alumina, and silica in cones 11 and 12.

Cone 13 stops bending for a few minutes when about half way down, and seems to melt rather sharply after this pause, at 1350°C, at least there is a negligible difference in the end points for the two rates of heating. This indicates a new reaction in cone 13.

In cones 15, 16, and 17, it appears that still another reaction is beginning but that it proceeds very slowly until a temperature of about 1485–1490° is reached, because cone 17 bends so slowly that the start can only be guessed and cone 18 has the same end point for the two rates of heating.

The precision attained in determining the end points above 1500°C is not great enough to give real significance to the differences in these points for cones 19 and 20.

The somewhat speculative statements in the preceding paragraphs are not idly made; they call attention to the plain facts that each cone is a little different from its neighbor and that any general statement describing the manner in which cones fuse should be limited to a small number in a short series.

Cones 23 to 38 were heated at 100° per hour, no attempt being made to study the effect of slow heating of these refractory cones whose bending intervals are generally much shorter than those of the lower series.

Sosman showed in a very simple manner that cones 28, 29, 30, and 31 could all be brought down at 1615°C, which is now found to be the end point of cone 28 heated at 100° per hour. From the experiments of Bowen and Greig[1] who discovered a eutectic of cristobalite and mullite melting at 1545°C it appears that cones 23, 26, and 27 and perhaps even higher ones could be brought down at 1545° or lower. The present authors have often observed in their labora-

[1] *Jour. Amer. Ceram. Soc.*, **7**, 238 (1924).

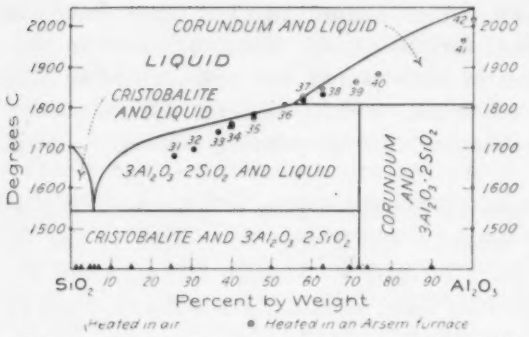

FIG. 4.—Equilibrium diagram of system $Al_2O_3 - SiO_2$, by Bowen and Greig, with end points of cones 31 to 42 plotted.

tories that refractory pyrometer-tubes formerly called sillimanite porcelain, all bend at 1540° or lower.

Bowen and Greig have explained these observations. Cones 31 to 42, which consist of the simple binary system Al_2O_3–SiO_2, can be placed as shown in Fig. 4 on the Bowen and Greig equilibrium diagram. It is evident that the lower cones of the series contain enough liquid above 1545° to come down at temperatures well below the liquidus when heated at 100° per hour, while cones 35 to 37 fuse so sharply that their end points lie very near the liquidus curve, and in fact agree with the curve within experimental error. Some of the cones above 36 would in all probability come down after a period of heating at 1810° or a few degrees higher, if they were not contaminated or in some way altered by heating at so high a temperature.

Cones 39 to 42 were not tested in an oxidizing atmosphere, but only in an Arsem furnace in which the atmosphere is highly attenuated although still somewhat reducing. Because of a slight reducing action of this atmosphere it is necessary, in order to minimize carbonization, to heat the cone material in the form of compact cylinders at a very rapid rate; hence, it is reasonable to expect that the deformation points determined thus will differ somewhat from the end points determined in air at a slower rate of heating. Therefore, to compare the two methods of heating, cones 34 to 38 inclusive were tested in the Arsem furnace after determining their end points in air. The results were very satisfactory and the subsequent measurements on cones 39 to 42 can properly be regarded as fairly trustworthy.

Cones 022 to 01
Heated in Furnace Gases

See Tables VII, VIII, IX, and X. Cones 022 to 017 exposed to the action of furnace gases containing 10% CO_2 behaved rather regularly when heated slowly but the first four of these were not fused successfully in such an atmosphere at 150° per hour. Cone 016 and possibly also 017 and 018 fused abnormally low in this atmosphere.

Cones 015 to 011 fused at too high a temperature when heated slowly, but when heated rapidly they bent and fused in a normal manner. Cone 012 was an exception to this, that is, when it was heated rapidly it fused more than 20° lower than when it was heated slowly, while the difference was only 8° when the cone was heated in air.[1] These differences between end points for fast and slow heating show the same general trend as those given in Table IV.

The data in Table VII show, as one might expect, that the effect of furnace gases depends upon their concentration and the time of exposure of the cones. Therefore, since the effects on cones 022 to 011 of an atmosphere of 10% CO_2 were generally small, and also since the differences in end points ("gas minus air") were in some cases within experimental error, none of this group was tested in an atmosphere of 5% CO_2.

Cones 010 to 01 were all stiffened on the surface by slow heating in 5% CO_2 and two of this group, 010 and 09, acted so erratically that the results were thrown out and in their place those obtained from special runs with only 3% CO_2 were substituted.

With slow heating the results on cones 08 to 01 show, when the experimental error is considered, what may be a gradual decrease in the effect of 5% CO_2, cone 01 being affected scarcely at all. The actual figures show, however, a maximum effect at cone 06, which is coincident with a maximum in the lime content.

With rapid heating in this atmosphere there is a gradual increase in the effect of CO_2 from cone 010 to 04, which is consistent with the gradual increase in the proportion of the more basic constituents present in each cone. At cone 03 there is a marked change in composition, to a higher percentage of clay, and possibly as a result of this change, cones 03, 02, and 01, as the data show, were not perceptibly altered by CO_2. Because the percentage of each constituent varies from one cone to the next, it is almost impossible to ascribe the effect of furnace gases to any single one of them.

The results obtained upon heating cones 09 to 04 in 10% CO_2 at 150° per hour are so unsatisfactory as to be almost worthless, showing that these cones should not be used under such conditions. Each value given in the table for this set of conditions is the mean of many repetitions; individual results varied in a few instances by 10° from the mean, and many results were cast out because of the manner in which the cone "came down." Most of the cones were so severely attacked by the furnace gas that they bent scarcely at all, except at the base where the skin broke or burst. That part of the cone pro-

[1] See foot note 1on page 715.

tected by the pat fused first and, in bloating, burst the hardened surface.

The descriptions of bending, bloating, and surface action, given in Tables VIII and IX, are brief but probably sufficient. It is impossible to be very exact in these descriptions.

Effect of SO_2

See Table X. M. C. Booze, Research Fellow at Mellon Institute for the Refractories Manufacturers Association, kindly sent out numerous inquiries concerning the amount of SO_2 in kiln gases. The information available was meager, but it supplied a reasonable basis for the selection of a proportion of SO_2 which would be roughly representative of conditions commonly met. Much of the sulphur found in the gases of some kilns comes from the ware; in such cases the composition of gases which surround cones in the kilns is a matter of doubt. However, it was thought that experiments with furnace gases containing 0.3 or 0.4% of SO_2 would supply the information sought.

Only a selected number of cones (see Table X) were subjected to sulphur-bearing gases. All these, with the exception of cone 011 which has a very small content of bases, fused at *higher* temperatures in such gases than in gases containing no appreciable percentages of sulphur. The differences given in the third and in the last columns of Table X represent the contributive effect of SO_2, that is, the differences in end points found in gases free from sulphur from those found in gases carrying sulphur.

Cones 017 and 016 were apparently unaffected by SO_3 or SO_2 so that the end points agreed with those observed when these two cones were heated in 10% CO_2 free from the sulphur oxides. The surface of cone 015 was attacked slightly and its end point was raised about 8°.

Cones 011, 010, and 09 were attacked severely and came down stiff. The end points observed under such a condition are of little value and the differences given in the table for these three cones should be regarded as merely indicative of the magnitude of the effects. The first two of these had a very thick, hardened skin with a "normal color" but where the skin burst at the base the inside appeared green or greenish yellow. In some cases the inside fused and ran out at the base of the cone.

Cones 02 to 4 bent and arched fairly well, the last three of the group bending the most nearly in a normal manner. The surfaces of all but the last, No. 4, were glassy and bumpy, and all were green, even cone 4 which contains iron only as an impurity and is white when fired in

sulphur free gases. The green color varied from the fairly deep shade produced in 02 to the very light shade in No. 4.

Cones 18, 19, and 20 bent mostly at the base and were perceptibly stiffened so that their end points were raised by 25°, indicating that there must have been a considerable absorption of SO_3 even at these high temperatures. No analyses of the fused cones were made, but there is no doubt that sulphates were formed. Orton[1] states that in one instance 2.5% of SO_3 was found in a cone which had been exposed to furnace gases containing sulphur oxides.

It seems strange that the surfaces of cones whose end points are raised by the action of SO_3 should be glassy when the cones are heated in an atmosphere containing this oxide. Only a detailed study of the action of the acid-forming oxide could furnish a satisfactory explanation of this enigma. The authors suggest, with diffidence, that SO_3 was dissolved in the original glass constituent of the cones, that this effect increased the solubility of certain particles otherwise relatively insoluble, and by so doing produced a glass having an increased viscosity.

Note on Grinding Off the Surface of a Cone before Using

Three No. 7 cones were mounted on a pat, one cone unaltered, one whose three sides had been sand-papered to remove the original surface, and one from which the surface of one side only had been removed. These were heated at 20° per hour in an atmosphere of 3% CO_2 (no SO_2) with the result that all were observed to come down together, that is, within experimental error, to "fuse" at the same temperature. This experiment was made to answer a question regarding the action of the original surface, raised during the course of the work. It seemed unnecessary to study this question further.

General Discussion

In firing clay ware the fundamental thing is the following of a prearranged time-temperature schedule and the final attainment of a certain temperature. Time is easily measured with the required accuracy, hence the process is fundamentally one of temperature control.

Pyrometers Temperatures are generally estimated by observing or measuring a physical change in a pyrometric device whose physical condition can be kept independent of all other factors but temperature. There are only a few principal types of temperature measuring instruments: (1) gas, liquid, and vapor thermometers, (2) resistance thermometers, (3) thermoelectric pyrometers, (4) radia-

[1] *Trans. Amer. Ceram. Soc.*, **3**, 198 (1901).

tion and optical pyrometers. These various types or kinds can be placed in two classes, namely, (1) the device itself is raised to the temperature being measured, and (2) the device is not raised to the temperature measured, but is used to gage the intensity of radiant energy, heat, or light, emitted by the hot body or furnace. Devices of the first class are inherently unsuitable for the measurement of temperatures above certain limits; the higher the temperature, the more difficult it is to find a substance which can withstand the high temperature without permanent change, or without change which is dependent on other things than temperature. For example, when a thermocouple is used at high temperatures it is always subjected to some alteration or contamination.

Thermocouples Do Not Give Same Readings Under All Conditions

One does not hesitate because of this to standardize or calibrate thermocouples, even though under some conditions, their performance may not be wholly satisfactory. Such calibration is carried out under definite and reproducible conditions, so selected that the performance of the thermocouple during the tests will be as satisfactory as possible. However, thermocouples are checked under actual conditions of use, whatever they may be, to determine as accurately as possible the corrections to the original calibration, which should be applied at the time of the check.

Standardizing Cones Same in Principle as for Thermocouples

Hence, one does not hesitate to determine the behavior of pyrometric cones under definite and reproducible conditions, and to determine also the magnitude of those errors which may be met during their use. In the present investigation, the cones, each one always mounted in a definite manner, have been heated at carefully controlled rates in clean air. This simple set of conditions can be maintained and reproduced with relative ease.

Rieke said that the end points of cones could never be determined once for all. The two principal reasons for this statement are: (1) cones are artificial mixtures not always the same but only approximately so, and (2) their defined end points are not invariants but depend upon rate of heating and, to some extent, upon furnace atmosphere, which may contaminate their substance.

It is believed that the confusion which has persisted in regard to the characteristics and proper function of cones is caused not only by the lack of accurate numerical data obtained under known conditions, but also by the complexity and variety of their reactions and the large number of different cones in common use, each having its own peculiarities. The confusion is undoubtedly augmented by the

refusal of many ceramists to think in terms of temperature, and also by the practice in their industry of using an indefinite scale of refractoriness while all other heat-process industries use a scale of temperature. Seger warned against this practice nearly forty years ago when discussing use of Bishof's standard refractory clays.

The following quotation from Day and Sosman[1] regarding the behavior of slow-melting substances, is repeated:

> The so-called melting interval of slow-melting compounds (quartz, albite, orthoclase) should be carefully distinguished from the "melting interval" of mixtures (lime-soda feldspars, impure natural minerals). The former melt and become amorphous very slowly, but their melting interval is an interval of *time*, whereas the melting interval of mixtures is an interval of *temperature*. The pure soda feldspar (albite) if held at a temperature slightly above its melting point for a sufficient length of time, will melt completely; the mixture, on the other hand, if held at a temperature within its melting interval, will melt in part, come to equilibrium, and remain indefinitely part crystalline and part liquid.

Pyrometric cones are, with few exceptions, mixtures; hence, the melting range or interval would be described as one of temperature. However, this is a secondary consideration because a cone always comes down before it is completely melted. It may come down after exposure for an interval of time at a constant temperature and in such cases its behavior resembles somewhat that of a slow-melting compound, but the cone in practical use is generally subjected to heating at a slowly rising temperature. Now, whether the temperature is rising or is constant the cone bends over slowly; consequently the end point is variable depending upon time, temperature, and atmosphere.

Rieke stated that cones are more or less like the ware. The cones differ from the ware, however, in that the cones must "fuse" while the ware is "maturing." If the ware at a certain schedule of heating is properly matured at the end point of some particular cone this schedule should be maintained. Experience has shown that if another schedule is followed the ware may not be properly matured at the same cone.

Cones Measure Temperatures and Not Effect on Wares

If the same schedule is followed and the kiln gases are the same the cone will always come down at the same temperature. Thus it measures the temperature at which the ware will mature with a controlled rate of heating and given character of kiln gases. It does not measure the combined effect on the ware of time, temperature, and kiln gases. Since its performance depends upon these three factors, the cone may, to some extent, serve to gage roughly their effects on the ware.

[1] *Amer. Jour. Sci.*, **31**, 341 (1911).

It may even be thought by some that in many cases the cone and the ware are so nearly similar that, for practical purposes, they may be regarded as identical, but experience proves that this is not the case and that the cone cannot be properly regarded as a true gage of the progress of the maturing of the ware. As examples of differences which can be expected between the cone and the ware, the differences in the characteristics of cones themselves may be cited, such as numbers 04 and 03, 8 and 9, 12 and 13, and lastly 010 and 011 fired in an atmosphere containing 0.35% of SO_2. (See Table X.)

The cones constitute a complete series of standard mixtures each of which will always, within tolerable limits, respond consistently to different conditions of firing, but they will not in respect to different conditions of firing in the same manner and degree as will the ware.

Effect of Contamination by Furnace Gases

The contamination of cones by furnace gases free from sulphur is ordinarily not serious because there is generally a fairly large excess of air in a ceramic kiln. The behavior of the higher cones indicates that they are little affected by a "neutral" or even slightly reducing atmosphere.

The effects of gases containing SO_2, shown in Table X, are both surprising and disappointing. The SO_3, which is probably the more active of the two oxides, proves to have a very powerful influence on the viscosity of the silicate mixtures. Certainly the effects of SO_2 (SO_3) in kiln gases should be studied more extensively than in the present investigation. They should be studied with simple and pure compounds, to prove, for instance, whether or not lime is especially to be blamed for the difficulty with SO_2, as has been guessed by others, and whether B_2O_3 is replaced and driven off by SO_3, and whether an iron oxide or silicate acts as an efficaceous catalyzer.

The data in Table X indicate that the end points of cones in kiln gases can be relied upon, in most cases, to about 25° if the SO_2 content is not greater than 0.3%. Fortunately there is a warning in the result obtained on cone 011 not to draw the general conclusion that SO_2 always raises the end point.

Comparison of Old Data with Present Results

An interesting comparison of all the principal data is presented in Table XI. In the old data more than one make of cones is represented and in no case were the conditions of heating clearly specified or controlled with sufficient accuracy; nevertheless, the differences between those data and the present results are, on the whole, remarkably small, a fact which requires explanation.

The differences in the data shown in column 2 of Table XI are small up to cone 26, because in the time of Seger a few of these cones were

compared with well-established melting points of metals. Above 1500°, the temperature scale was very uncertain, and for this reason the values given in the original circular for the highest cones were almost pure guesses and differed from the values obtained by us by as much as 80°C.

In 1910, the values as amended were supposed to fit slow firing in industrial kilns, and from cones 1 to 35 the agreement with the present results for slow firing in furnace gases is excellent.

The almost consistently high values of Hofmann (1907–1909) were obtained with a rate of heating of 300° an hour, and hence they *should be* generally higher. Hofmann's 1911 tests in industrial kilns were made without control of the rate of heating which was probably slower than 20° per hour.

Rieke, in 1911, used fuel-fired kilns without any adequate control; hence, the present authors feel justified in averaging all of Rieke's data for slow rates. His individual results varied far outside the differences shown in Table XI.

Brown and Murray, in 1913, either allowed their kilns to heat more slowly than they intended near the end-points of the cones or else their temperature measurements are in error, for it is unlikely that such large differences as appear in column 7 could be caused by differences in furnace atmospheres alone; moreover, the uniformity of the differences in this column point to errors in temperature measurements because the cones would not respond with such regularity to differences in heating conditions.

Fieldner, Hall, and Feild heated the cones at a very rapid rate and thus obtained high results, but even so their result for cone 8 is evidently too high.

Cone 35 and Kaolin

Cone 35, which has a fairly sharp melting point, has always been made from pure grades of kaolin, hence comparison of the various determinations of the end point of this particular cone is significant. The data are given in Table XII.

The melting points given for the various samples are quite consistent with the analyses. The analysis given by Seger for Zettlitz kaolin, which analysis probably fits the material tested by Hofmann, is:

	Per cent		Per cent
Silica	46.87	Magnesia	trace
Alumina	38.56	Alkali	1.06
Iron oxide	0.83	Loss on ignition	12.73
Lime	trace		

The analysis by the Bureau of Standards of the Florida kaolin used for Orton cone 35 is:

	Per cent		Per cent
Silica	46.83	Magnesia	trace
Alumina	40.83	Total alkali	0.24
Iron oxide	0.65	Loss at 105°	0.60
Titanium oxide	0.34	Loss on ignition	10.56
Lime	0.20	Phosphoric anhydride not detected on one gram	

The figure 1770° given in the 1910 circular of the *Tonindustrie Zeitung* is probably the value accepted at that time for the melting point of platinum, for it was known then that cone 35 melted very nearly at the melting of that metal.

Summary

The characteristics of pyrometric cones have been determined under definite and reproducible conditions of heating. The temperatures of the "end points" of a complete set of cones together with their bending intervals were measured at carefully controlled rates of heating in clean air and in various kiln gases.

With a few exceptions the end points were found to be higher when the rate of heating was 150°C per hour than when the rate was 20° per hour. The maximum difference in this investigation is only 58°, and in but five cases is the difference more than 40°. In many instances the differences are almost negligible or within experimental error.

Under slow heating in gases free from SO_2 the end points of cones 015 to 01 are somewhat higher than those found in clean air. Cones 022 to 016 and 1 to 42 were acted upon only slightly by kiln gases free from SO_2.

A standardized method of testing has been developed, which is applicable not only to the examination of cones but to testing for the refractoriness of any ceramic material or product. The accuracy obtained by this method was better than 5° up to 1400°C and better than 10° from that temperature up to 2000°.

Each cone should be considered separately. "Cone intervals" and "bending intervals" should not be taken as uniform for all the cones but as shown for each in the tables here given.

Cones are properly used only for the measurement of temperatures. The cones will always come down at the same temperatures if the same heating schedule is always followed and if there have been no effects from the variations in the kiln gases.

A cone in a kiln does not measure the combined effect of time, temperature, and kiln gases upon the progress of maturing of the ware.

The combined use of cones and pyrometers is recommended for kiln control, but the authors believe that cones are inherently unsuited to laboratory tests of the refractoriness of clay products.

TABLE I

END POINTS OF CONES IN DEGREES CENTIGRADE
(Rate: 20°C per hour)

Cone No.	Sept. 10–11	Sept. 12–13	Sept. 15–16	Sept. 19–20	Sept. 22–23	Sept. 24–25	Sept. 26–27	Sept. 29–30	Oct. 1–2	Oct. 6–7	Oct. 8–9	Mean	Max. diff. from mean
022	586	588	——									587	1
021	595	595	591									594	3
020	622	628	625	620								624	4
019				626	628							627	1
018				669	671							670	1
017					716	721						718	3
016						737	735					736	1
015						773	770					772	2
01							796	795				795	1
013								825	824			8 5	1
012*		Aug.	Aug.	Aug.	Aug.			884	888	——	883	8 5	3
011		11–12	13–14	15–16	18–19	Aug.	Aug.	Aug.	876	875	871	874	3
010		890				20–21	22–23	25–26		891	886	889	3
09		927						928				927	1
08		946						944				945	1
07			978					977				977	1
06			1001				1006					1004	3
05			1029				1032					1030	2
04				1051			1054					1052	2
03				1082	1082							1082	0
02				1097	1093	1098						1096	3
01					1115	1108						1111	4
1						1126						1126	–

*See foot note page 715.

TABLE II

END POINTS OF CONES IN DEGREES CENTIGRADE
(Rate: 150°C per hour)

Cone No.	Oct. 10–11	Oct. 13–14	Oct. 15–16	Oct. 17–18	Oct. 20–21	Oct. 22	Oct. 24	Oct. 28	Oct. 29	Oct. 30	Mean	Max. diff. from mean
022	603	603	608								605	3
021	620	615	617								617	3
020	647	650	652	647							649	3
019				661	663						662	1
018				718	719						718	1
017					770		775				772	3
016						794	793				794	1
015						807	807				807	0
014						829		828			828	1
013								860	861		860	1
012*	June	June	June					876	876	878	877	1
011	18	19	20	June					905	905	905	0
010	895	894		21						899	896	3

*See foot note page 715.

Cone No.	June 18	June 19	June 20	June 21	June 23	June 24	June 25	June 26	June 27	June 28	Mean	Max. diff. from mean
09	928	925	934								929	5
08	953	946	950	956							951	5
07			987	989	987						988	1
06				1011	1015	1019					1015	4
05					1040	1040	1037				1039	2
04						1063	1062	1062			1062	1
03							1114	1116	1114		1115	1
02								1128	1124	1126	1126	2
01									1144	1147 1147	1146	2

TABLE III

BEHAVIOR OF CONES 022 TO 011 HEATED IN AIR

Cone No.	Heating rate, °C/hr. up to temp. in next column	Rate changed at this temp. to that in next col.	Rate maintained to end point	Bending: Arching	Bending: At base	Bloating: Before end point	Bloating: Above end point	Remarks
022	70°C	230°C	20°C	Fair	Slight	slight	40°C severe	OK
	125	500[1]	20	Bad	N	—	—	6°C low
	40[2]	500[2]	150	Fair	Slight	slight	—	OK
	42	510[3]	150	"	"	"	—	OK
	500	500[4]	150	bad	?	"	—	OK
021	70	230	20	N	N	none	30°C slight	OK
	125	500	20	N	N	"	—	OK
	40[2]	500[2]	150	N	N	"	none	OK
	42	510[3]	150	N	N	"	"	OK
	500	500[4]	150	bad	?	slight	severe	8°C low
	125	525[5]	150	"	?	"	"	7°C low
020	70	230	20	N	N	none	—	OK
	125	500[1]	20	N	N	"	—	OK
	200	230	20	N	N	"	50°C none	OK
	40[2]	500[2]	150	N	N	"	—	OK
	42	510[3]	150	N	N	"	—	OK
	500	500[4]	150	—	—	severe	—	2°C low
	125	525[5]	150	—	—	"	—	7°C slight
	20	500[6]	150	N	N	none	70°C slight	OK
019	200	230	20	N	N	"	—	OK
	70	215	20	N	N	"	—	OK
	20[6]	500[6]	150	N	N	"	60°C slight	OK
018	200	230	20	N	N	"	—	OK
	70	215	20	N	N	"	—	OK
	20[6]	500[6]	150	N	N	"	50°C none	OK
017	70	215	20	N	N	"	—	OK
	160	160	20	N	N	"	—	OK
	20[6]	500[6]	150	N	N	"	—	OK
016	160	160	20	N	N	none	none	OK
	110	440	20	N	N	"	"	OK
	250	500[7]	150	N	N	"	"	OK
	20[8]	680	150	N	N	"	"	OK

TABLE III (*concluded*)

Cone No.	Heating rate, °C/hr. up to temp. in next column	Rate changed at this temp. to that in next col.	Rate maintained to end point	Bending: Arching	Bending: At base	Bloating: Before end point	Bloating: Above end point	Remarks
015	160	160	20	N	N	none	none	OK
	110	440	20	N	N	"	"	OK
	250	500[7]	150	N	N	"	"	OK
	20[8]	680	150	N	N	"	"	OK
014	110	440	20	N	N	"	"	OK
	100	300	20	N	N	"	"	OK
	250	500[7]	150	N	N	"	"	OK
013	100	300	20	N	N	none	none	OK
	250	390	20	N	N	"	"	OK
	250	500[7]	150	N	N	"	"	OK
	250	560	150	N	N	"	"	OK
012	100	300	20	N	N	none	none	OK
	250	300	20	N	N	"	"	OK
	250	500[7]	150	N	N	"	"	OK
	250	560	150	N	N	"	"	OK
011	250	300	20	N	N	none	none	OK
	90	300	20	N	N	"	"	OK
	250	560	150	N	N	"	"	OK

N = Normal
OK = Data used

[1] Held 14 hours at 500°C
[2] 60°C/hr. to 465°C (held 18 hours) and at 500°C held 4 hours
[3] Held 14 hours at 510°C
[4] Held 2 ½ hours at 500°C
[5] Held 3 hours at 525°C
[6] 130°C/hr. to 265°C, held 1 hour at 500°C
[7] Held 1 ½ hours at 500°C
[8] 80°C/hr. to 350°C

TABLE IV

END POINTS AND INTERVALS OF CONES 022 TO 01 (Heated in Air)

Rate °C/hr. Cone No.	20°C End point	150°C End point	Diff. fast–slow	20°C Bending interval	150°C Bending interval	20°C Cone interval	150°C Cone interval
022	585°C	605°C	18°C*	45°C	55°C	10°C	10°C
021	595	615	23	45	45	30	35
020	625	650	25	30	25	5	10
019	630	660	35	30	20	40	60
018	670	720	48	30	30	50	50
017	720	770	54	30	30	15	25
016	735	795	58	35	55	35	10
015	770	805	35	30	45	25	25
014	795	830	32	45	40	30	30

TABLE IV (*concluded*)

Rate °C/hr. Cone No.	20°C End point	150°C End point	Diff. fast–slow	20°C Bending interval	150°C Bending interval	20°C Cone interval	150°C Cone interval
013	825	860	36	45	50	60	15
012§	885	875	− 8	85	45	−10	30
011	875	905	31	65	65	15	−10
010	890	895	7	30	25	40	35
09	930	930	1	35	40	15	20
08	945	950	6	55	60	30	40
07	975	990	10	35	50	30	25
06	1005	1015	11	25	35	25	25
05	1030	1040	9	30	30	20	20
04	1050	1060	10	40	40	30	55
03	1080	1115	33	40	35	15	10
02	1095	1125	30	35	35	15	20
01	1110	1145	36	50	45	15	15

*Values not rounded as in columns 2 and 3.

§See foot note page 715 regarding a second lot of cones 012.

TABLE V

HEATING SCHEDULE AND BEHAVIOR OF CONES 010 TO 4 HEATED IN AIR

Cone No.	Heating rate, °C/hr up to temp. in next column	Rate changed at this temp. to that in next col.	Rate maintained to end point	Behavior	Color	Remarks
010	41°C	725°C	20°C	N		OK
	90	475	20	N		OK
	250	560	150	N		OK
	270[1]	670	150	N		OK
09	41	725	20	N		OK
	35	825	20	N		OK
	270[1]	670	150	N		OK
08	41	725	20	N		OK
	35	825	20	N		OK
	270[1]	670	150	N		OK
07	43	280	20	N		OK
	35	825	20	N		OK
	270[1]	670	150	N		OK
06	43	280	20	N		OK
	40	905	20	N		OK
	270[1]	670	150	N		OK
05	43	480	20	N		OK
	40	905	20	N		OK
	270[1]	670	150	N		OK
04	39	955	20	N		OK
	40	905	20	N		OK
	270[1]	700	150	N		OK
03	39	955	20	N		OK
	40	990	20	N		OK
	330[2]	1045	20	N	Special test	OK
	270[1]	800	150	N	olive	OK
02	39	955	20	N	"	OK

Chestnut brown to olive–20° per hour
Brown to russet–150° per hour

TABLE V (*concluded*)

Cone No.	Heating rate, °C/hr. up to temp. in next column	Rate changed at this temp. to that in next col.	Rate maintained to end point	Behavior	Color	Remarks
	40	990	20	N	olive	OK
	40	1015	20	N	"	OK
	330[2]	1045	20	N	Special test	OK
	270[1]	800	150	N	olive	OK
01	40	990	20	N	"	OK
	40	1015	20	N	"	OK
	330[2]	1045	20	N	Special test "	OK
	270[1]	800	150	N	buff-olive	OK
	450	900	150	N	brown-green	OK
1	40	1015	20	N	buff-olive	OK
	430	1010	20	N	"	OK
	450	900	150	N	brown-green	OK
2	430	1010	20	N	–	OK
	450	900	150	N	yellow-green brown tinge	OK
3	430	1010	20	N	buff-olive	OK
	450	900	150	N	light yellow-gray	OK
4	430	1010	20	N	white	OK
	450	900	150	N	"	OK

OK = data used

[1] Heated to 400°C in 1 hour

[2] Heated to 675°C at 500°C per hour

TABLE VI

CONES 1 TO 42

Cones 1–38, Mean of Data, Gas and Air

Average departure from mean ("gas" and "air") 1.5°C

Rate °C/hr. Cone No.	20 End point	150 End point	Diff. fast–slow	20 Bending interval	150 Bending interval	20 Cone interval	150 Cone interval
1	1125°C	1160°C	34°C*	30°C	45°C	10°C	5°C
2	1135	1165	28	30	45	10	5
3	1145	1170	25	30	40	20	20
4	1165	1190	26	40	35	15	15
5	1180	1205	28	40	50	10	25
6	1190	1230	39	40	35	20	20
7	1210	1250	43	40	60	15	10
8	1225	1260	35	45	55	25	25
9	1250	1285	32	65	115	10	20
10	1260	1305	44	40	95	25	20
11	1285	1325	36	70	80	25	10
12	1310	1335	27	80	45	40	15

*Values not rounded as in columns 2 and 3.

TABLE VI (*concluded*)

Rate °C/hr. Cone No.	20 End point	150 End point	Diff. fast–slow	20 Bending interval	150 Bending interval	20 Cone interval	150 Cone interval
13	1350	1350	− 3	70	55	40	50
14	1390	1400	8	100	70	20	35
15	1410	1435	26	85	115	40	30
16	1450	1465	16	70	125	15	10
17	1465	1475	7	50–75 ?	125	20	15
18	1485	1490	2	90	85	30	30
19	1515	1520	3	100	70	5	10
20	1520	1530	8	—	60		50
23		1580			30		15
26		1595			10		10
27		1605	Cones 23 to 38		15		10
28		1615	heated at 100°C per		10		25
29		1640	hour		30		10
30	In Arsem	1650			25		30
31	furnace at	1680			25		20
32	600°C	1700			15		45
33	per hr.	1745			30		15
34	1755	1760			15		25
35	1775	1785			15		25
36	1810	1810			25		10
37	1830	1820			5		15
38	1850	1835			15		
39	1865						
40	1885						
41	1970						
42	2015						

TABLE VII

END POINTS OF CONES 022 TO 01 (Heated in Furnace Gases)

Rate °C/Hr. Cone No.	20°C 10% CO_2	Diff. "gas"–"air"	150°C 10% CO_2	Diff. "gas"–"air"	Diff. fast–slow	20°C Cone interval
022	580°C	− 5°C*	—		—	20°C
021	600	+ 4	—		—	20
020	620	− 4	—		—	5
019	625	− 4				45
018	670	0	705°C	−11°C*	37°C*	40
017	710	− 6	760	−14	46	15
016	725	−10	780	−13	55	55
015	780	8	810	4	31	40
014	820	22	830	4	14	20
013	840	18	860	−1	17	55
012§	895	10	870	−8	−26	−5
011	890	16	905	+1	16	0

*Values not rounded as in columns 2 and 4.

§See foot note on page 715 regarding a second lot of cones 012, which were tested only in air. It is probable that the cones of this second lot would behave in a more nearly normal manner when heated in "10 %CO_2" than did those of the first lot.

TABLE VII (*concluded*)

Rate°C/Hr. Cone No.	20°C 5% CO_2	Diff. "gas"–"air"	150°C 5% CO_2	Diff. "gas"–"air"	150°C CO_2 10%	Diff. "gas"–"air"	Diff. fast–slow	20°C Cone interval
010	(890)[1]°C	(3)°C*	895°C	− 1°C*	895°C	−3°C*	(3)°C*	40°C
09	(930)[1]	(2)	935	5	945	17	(4)	45
08	975[2]	29	955	5	960	11	−18	25
07	1005	30	995	6	1000	14	−13	40
06	1040	35	1020	6	1035	19	−19	10
05	1050	20	1050	12	1050	11?	1	25
04	1075	22	1075	13	1085	23	1	25
03	1100	16	1115	− 1	1115	1	16	5
02	1105	10	1130	3	1130	3	23	10
01	1115	4	1150	1	1145	− 3	33	10

([1])3%CO_2
([2])955° in 3%CO_2
([3])5%CO_2

TABLE VIII

BEHAVIOR OF CONES 022 TO 4 HEATED IN FURNACE GASES FREE FROM SO_2
GAS ANAL. 10% CO_2

Cone No.	Rate of heating °C per hour	Bending	Bloating below end point	Surface action "skin effects"	Color	Remarks
022	20	fair	some	severe		OK
021	20	at base	severe	"		OK
020	20	" "	"	slight		OK
019	20	" "	none	slight		OK
	150	" "	severe	severe		NG
018	20	good	slight	slight		OK
	150	fair	very "	none		OK
017	20	normal	none	slight		OK
	150	fair	slight	none		OK
016	20	normal	none	none		OK
	20	"	"	"		OK
	20	"	"	"		OK
	150	fair	"	slight		OK
015	20	normal	"	none		OK
	20	"	"	"		OK
	20	"	"	"		OK
	150	fair	"	slight		OK
014	20	normal	"	none		OK
	150	fair	"	very slight		OK
013	20	normal	"	none		OK
	150	"	"	very slight		OK
	150	"	"	" "		OK
012	20	"	"	none		OK
	150	"	"	"		OK

TABLE VIII (*concluded*)

Cone No.	Rate of heating °C per hour	Bending	Bloating below end point	Surface action "skin effects"	Color	Remarks
011	20	"	"	"		OK
	150	"	"	none ?		OK
	150	"	"	"		OK
010	20	(stiff)	none	severe	—	NG
	150	at base[1]	some	"	—	fair
	150	" "	some	worse	green to brown[2]	fair
09	150	" "	none	severe	" " "	fair
	20	(stiff)	"	"	—	NG
08	150	at base	"	"	red-brown	fair
	20	(stiff)	"	"	" "	NG
07	150	at base	"	"	green-brown	fair
06	150	" "	"	"	brown	fair
05	150	" "	"	shows	red-brown	fair
04	150	" "	"	"	brown	fair
03	150	" "	"	slight	"	fair
02	150	" "	"	"	light brown	fair
01	150	fair	none	slight	light brown	fair
1	20	normal	"	none?	—	OK
	20	"	"	"	dark green	OK
	150	"	slight	none	gray	OK
2	20	"	none	none?	?	OK
	20	"	"	none	green-gray	OK
	150	"	slight	"	gray	OK
3	20	"	none	none?	?	OK
	20	"	"	none	light-gray	OK
	150	"	"	"	" "	OK
4	20	"	"	"	white	OK
	150	"	"	"	"	OK

OK = Data Used

[1] Cones 010 to 02 arched slightly, bent most at base

[2] Bloating broke skin. Inside of cone greenish

TABLE IX

BEHAVIOR OF CONES 010 TO 3 HEATED IN FURNACE GASES FREE FROM SO_2

GAS ANAL. 5% CO_2

Cone No.	Rate of heating °C per hour	Bending	Bloating	Surface action	Color	Remarks
010	150	(stiff)	some	severe	–	fair
	20[1]	at base	slight	"	green to brown	"
09	150	fair	"	some	red-brown	OK
	20[1]	at base	none		" "	fair
	20[1]	good	"	slight	brown	"
08	20	fair	slight	"	red-brown	OK
	20[1]	"	none	"	brown	OK
	150	normal	"	v. "	"	OK
07	20	fair	"	"	green to brown	OK

TABLE IX (*concluded*)

Cone No.	Rate of heating °C per hour	Bending	Bloating	Surface action	Color	Remarks
	20[1]	"	"	"	red-brown	OK
	150	normal	"	v. "	" "	OK
06	20	good	"	v. "	" "	OK
	150	normal	"	v. "	brown	OK
05	20	good	"	v. "	red-brown	OK
	150	at base	"	slight	" "	NG
	150	normal	"	v. "	" "	OK
	150	"	"	"	" "	OK
04	20	at base	"	"	" "	fair
	20	" "	"	some	brown	NG
	150	normal	"	v. slight	"	OK
	150	"	"	"	"	OK
03	20	at base	"	some	"	fair
	150	normal	"	v. slight	"	OK
02	20	"	"	"	"	OK
	20	"	"	"	"	OK
	150	"	"	"	"	OK
01	20	"		"	light brown	OK
	150	"	"	"	" "	OK
1	20	normal	"	v. "	light brown	OK
	20	"	"	"	"	OK
	20	"	"	"	"	OK
	150	"	"	none	"	OK
2	20	"	"	"	"	OK
	20	"	"	"	"	OK
	150	"	"	"	"	OK
3	20	"	"	"	"	OK
	20	"	"	"	"	OK

[1] CO_2 reduced to 3%.

TABLE X

BEHAVIOR OF TYPICAL CONES IN GASES CONTAINING SULPHUR OXIDES

Heating at 150°C/hr.			Gas anal. 5% CO_2, 0.35% SO_2		
Cone No.	End point	Effect on end point	Cone No.	End point	Effect on end point
017	760°C	*	02	1165°C	36°C
016	780	*	01	1175	27
015	820	+ 8°C	1	1180	15
			2	1180	20
011	900	− 4	3	1185	16
010	930	37	4	1200	11
09	950	16		10% CO_2 0.35% SO_2	
			18	1510	24
			19	1540	25
			20	1555	26

*Not run in 5% CO_2 free from SO_2

Would not "come down" in 10% CO_2 +0.35% SO_2

TABLE XI

DIFFERENCES OF OLD DATA FROM AUTHORS' RESULTS*

Cone No.	Original circular	1910 circular	Hofmann 1907–09	Hofmann 1911	Rieke 1911	Brown and Murray 1913	Fieldner, Hall, and Feild 1918
022	−15°C[1]	20°C[2]	[3]	[4]	15°C[5]	[6]	[7]
021	5	50			55		
020	0	50			50		
019	20	65			55		
018	−10	40			25		
017	−30	20			5		
016	−25	25			5		
015	− 5	10a			20a		
014	0	− 5a			−30a		
013	0	− 5a			−15a		
012	15	+ 5a			+ 5a		
011	15	−10a			5a		
010	55	0a			40a	0°C	
09	40	−10a			30	− 5	
08	40	−15a			45	10	
07	20	−40a			30	−35	
06	15	−60a			15	−45	25°C
05	10	−50a			30	−25	−
04	10	−55a			25	−30	25
03	−25	−60a			10	−45	−
02	−15	−45a			20	−40	55
01	−15	−35a			25	−35	−
1	−10	−25a			20	−40	20
2	5	−15a		− 5	15	−40	15
3	20	− 5a		5	10	−40	−
4	25	− 5a	45	0	− 5	−50	65
5	25	5a	25	−	− 5	−45	−
6	20	10a	35	−	−15	−50	55
7	20	20	40	−25	−20	−60	−
8	30	25	50	−20	0	−55	105
9	25	30	55	−20	5	−50	−
10	25	40	50	−15	0		30
11	25	35	45	−	0		40
12	35	40	50	−	0		
13	40	30	55	−25	−15		
14	10	20	25	− 5	−15		
15	−10	25	10	−	5		
16	−15	10	10	−40			
17	− 5	15	20	−50			
18	0	15	35				
19	− 5	5	25				
20	0	10	30				
23	10	−	10				
26	60	−10	20				
27	65	5	30				

TABLE XI (*concluded*)

Cone No.	Original circular	1910 circular	Hofmann 1907–09	Hofmann 1911	Rieke 1911	Brown and Murray 1913	Fielder, Hall and Feild 1918
28	80	20	30				
29	70	10	30				
30	80	20	15				
31	70	10	30				
32	75	15	15				
33	45	−15	−25				
34	50	−10	−20				
35	45	−15	−25				
36	40	−20					
37	50	5					
38	55	15					
39		15					
40		35					
41		−10					
42		−15					

*Comparisons are made with authors' results under conditions most nearly alike. Differences are caused by differences in cones themselves as made by different manufacturers, by conditions of heating, and by errors in temperature measurements.

a The "a" series of cones.

[1] The original circular was a pretty fair guess. Differences from authors' results in air at 150°C per hour.

[2] Differences from authors' results in gas at 20°C per hour.

[3] Hoffman's data corrected for temperature scale. Data obtained by very rapid heating in air.

[4] Trials of a few cones in industrial kilns. Conditions not stated. Data corrected as in (3).

[5] Rieke used kilns fired with coal or wood, rate of heating controlled roughly. No data on atmosphere. Mean of results at different slow rates.

[6] First data on Orton cones. Fired slowly in kilns using natural gas. Data on four different rates erratic. Results have been averaged. No condition or temperature measurements accurately described.

[7] Heated very rapidly in air. Temperature measurements doubtful. Poor "black body" conditions.

TABLE XII

MELTING POINT OF CONE 35 AND KAOLIN

Authority	Year	Material	Melting point
Tonin. Zeit. Circular	1910	Zettlitz kaolin cone 35	1770°C
Hofman	1911	" " "	1760[1]
Kanolt	1912	English "	1745[2]
Bowen and Greig	1924	Synthetic $Al_2O_3.2SiO_2$	1790[3]
Authors	1925	Florida kaolin cone 35	1785[4]
"	1925	" " "	1775[5]

[1] Very rapid heating in air

[2] Very rapid heating in vacuum, slightly reducing

[3] From equilibrium diagram for system Al_2O_3-SiO_2

[4] Heating 100°C/hr. in air

[5] Heating 600°C/hr. as in (2)

TABLE XIII

END POINTS AND INTERVALS OF PYROMETRIC CONES (Heated in Air)

Rate °C/hr. Cone No.	20°C End point	150°C End point	20°C Bending interval	150°C Bending interval	20°C Cone interval	150°C Cone interval
022	585°C	605°C	45°C	55°C	10°C	10°C
021	595	615	45	45	30	35
020	625	650	30	25	5	10
019	630	660	30	20	40	60
018	670	720	30	30	50	50
017	720	770	30	30	15	25
016	735	795	35	55	35	10
015	770	805	30	45	25	25
014	795	830	45	40	30	30
013	825	860	45	50	15	15
012	840	875	50	85	35	30
011	875	905	65	65	15	−10
010	890	895	30	25	40	35
09	930	930	35	40	15	20
08	945	950	55	60	30	40
07	975	990	35	50	30	25
06	1005	1015	25	35	25	25
05	1030	1040	30	30	20	20
04	1050	1060	40	40	30	55
03	1080	1115	40	35	15	10
02	1095	1125	35	35	15	20
01	1110	1145	50	45	15	15
1	1125	1160	30	45	10	5
2	1135	1165	30	45	10	5
3	1145	1170	30	40	20	20
4	1165	1190	40	35	15	15
5	1180	1205	40	50	10	25
6	1190	1230	40	35	20	20
7	1210	1250	40	60	15	10
8	1225	1260	45	55	25	25
9	1250	1285	65	115	10	20
10	1260	1305	40	95	25	20
11	1285	1325	70	80	25	10
12	1310	1335	80	45	40	15
13	1350	1350	70	55	40	50
14	1390	1400	100	70	20	35
15	1410	1435	85	115	40	30
16	1450	1465	70	125	15	10
17	1465	1475	50–75?	125	20	15
18	1485	1490	90	85	30	30
19	1515	1520	100	70	5	10
20	1520	1530	—	60		50

TABLE XIII (*concluded*)

Rate °C/hr. Cone No.	20°C End point	150°C End point	20°C Bending interval	150°C Bending interval	20°C Cone interval	150°C Cone interval
23	In Arsem	1580		30		15
26	furnace at	1595		10		10
27	600°C	1605		15		10
28	per hr.	1615		10		25
29		1640		30		10
30		1650		25		30
31		1680		25		20
32		1700		15		45
33		1745		30		15
34	1755	1760		15		25
35	1775	1785		15		25
36	1810	1810		25		10
37	1830	1820		5		15
38	1850	1835		15		
39	1865					
40	1885					
41	1970					
42	2015					

Cones 23 to 38 heated at 100°C per hour

The temperatures in the above table, which have been determined under standardized and reproducible conditions (controlled rate of heating in clean air) will apply with fair approximation for the cones when heated in kilns where the gases are normally oxidizing and free from sulphur oxides. If the cones show a visible hardening of the surface or a skin effect resulting from exposure to kiln gases containing insufficient oxygen, small corrections may be necessary. Such surface action is most frequently noticed with cones 015 to 01. In kilns fired with fuel containing appreciable amounts of sulphur, or where the ware gives off sulphur dioxide the end points may be noticeably different from those given in the table.

Discussion

H. B. HENDERSON: There is one very important factor in firing clay ware, in the behavior of cones in testing and in use, which has not been considered by the authors. This factor is the effect of absorbed or deposited carbon in ceramic products. All ceramic ware are effected, some detrimentally, but in others the effect is intentional because of the color value, as for example the russet color of salt-glazed products and flashed fire clay products.

It is well known that methane, the chief constituent of coal gas and natural gas, readily dissociates at temperatures above 800°C and that carbon is one of the resulting products. It is this element, in a nascent state, that is superficially absorbed by the ware or deposited on the surface with slight penetration into the ware. The dissociation appears to be a surface condition; *i.e.*, it seems to be at a maximum at the surface of red hot cones or clay ware. The carbon when deposited under these conditions is hard and lustrous and apparently graphitic, and it is more difficult to burn out than the soft sooty variety known as lamp black. This lustrous graphite carbon may sometimes be seen

in coke surfaces, but the best examples are the "horns" of gas carbon that often build up in the throats of improperly fired natural gas furnaces, a hard, lustrous cone of carbon, infusible, and measurably non-combustible.

Cones are very seriously affected by such carbon deposits or absorptions as I have frequently seen in tests which have been sent into the laboratory for an explanation of their erratic behavior.

I reported[1] the first results of a series of observations on the effect of carbon on clay ware. Portions of the article were deleted by the editor and practically all reference to the effect of carbon was omitted. The editor graciously passed the statement that salt glazes contain carbon taken up as above outlined, and he permitted the further statement that the carbon, likely in the form of graphite, affects or influences crystal growth to which the color of salt glazes and flashed fire bricks is due, and in this line of ceramic products we have a notable example of the effects of carbon, a desirable effect because of the color and no harm to the ware itself.

In a number of factories, the dark russet color or a light straw color is developed at will by the method of firing and cooling. In the dark-colored product the firing conditions are strongly reducing and the carbon absorption is high, whereas in the light-colored product oxidizing conditions are maintained as fully as it is possible to do with the result of very low absorption. This has no bearing on the behavior of cones except as further evidence of the development and control of carbon in kiln gases and its absorption into the surface of the ware.

In various porcelain bodies the effect of the deposited carbon is very serious and it may entirely vitiate the value of pyrometric cones.

Figure 1 shows three pats of cones, in which are cones 9, 10, 11, all from the same boxes of cones, that is, the same batches. Plaques No. 1 and No. 2 were fired in a commercial kiln and were returned to the laboratory for an explanation of their erratic behavior. Plaque No. 3 was then fired in a test kiln.

FIG. 1.

The cones on No. 1 and No. 2 have a hard, dry, lusterless surface showing that there has been no fusion, no softening of the surface shell, due to the fact that carbon has been absorbed and the shell

[1] *Jour. Amer. Ceram. Soc.*, **1**, 148–59 (1918).

made more refractory in consequence. The fireclay body in which the cones were set has a beautiful golden color such as is produced in fire-flashed brick.

Since the commercial kiln cones were being used as temperature guides and because they did not go over, the kiln temperatures were carried higher without affecting the refractory shell but the normal interior of the cones softened, became fluid, and ran out at the bottom forming a puddle of fused glass in which stood the refractory hollow cone shell, but it subsequently toppled over without bending and without having its edges rounded by fusion. Number 9 cone did not topple over but stood erect, merely settling down into the soft glass in the hold in the pat. The No. 3 pat shows the normal behavior of these cones when properly treated.

Bradshaw and Emery[1] reported an investigation demonstrating conclusively that methane dissociates in contact with the surface of cones under fire, and that carbon develops and is absorbed by the ware thus forming a refractory shell that may support the cone and hold it erect until the interior fuses and runs out at the base leaving the hollow shell. This in the white cones becomes dark gray in color due to the deposit of carbon.

Since their work included cones of English and German manufacture, it is evident that this behavior under certain firing conditions is not limited to cones of American manufacture.

The carbon develops under strongly reducing kiln conditions, weak draft, closed fires, and deep fuel beds, in other words the kiln atmospheres which the sewer pipe and flashed face brick manufacturers develop to produce the russet color effects, and it carbonizes the cone surfaces and makes their use of no value. Especially is this true if the cones are so placed that they get flame contact.

It is too common a practice to place cones on a ledge of ware in the wicket space, where the gases immediately from the bags are reducing in spite of their air excess, and where the cones are bathed in flaming gases with each firing, and where they become coated with ash dust. Under such conditions cones cannot function properly. In any instance where the cones do not bend normally, where the edges do not soften and become rounded, the firing conditions are at fault.

EDWARD SCHRAMM: A word of appreciation should be given to Dr. Fairchild for this careful investigation of pyrometric cones and especially to the general conclusion that cones are essentially temperature measuring devices. A cone will come down over a range of temperatures depending on the firing curve followed, but under these

[1] *Trans. Ceram. Soc.* (Eng.), **21** [2], 117 (1922).

circumstances identical cone indications do not mean the same thing since it is only rarely and by accident that the work can have the same thermal characteristics as the cone. The best procedure, therefore, is to take care of the time by means of a clock, *i.e.*, to follow a definite time-temperature curve, in which case, as shown by Dr. Fairchild, the cones are quite satisfactory for the measurement of temperatures. There will be quite a variation in the temperature indicated by a given cone from plant to plant, but in spite of that it would be possible to devise a cone-temperature scale for average conditions which would fit a large number of cases. If we were starting anew, it might be best to avoid such a scale; but there is actually current, or at least printed in all books on ceramics, an erroneous scale dating back to Seger and sedulously copied ever since. It would do no harm to get out a new scale which would come a little nearer the truth.

If cones are merely for the measurement of temperatures we might ask why not dispense with them and use thermocouples. It is entirely a matter of convenience. Cones can be distributed throughout a kiln in a manner not feasible with thermocouples.

I do not agree that the cones cannot be used for measuring the rate of heating. A kiln can be operated so as to bring down successive cones in definite intervals of time and so we can come quite near to following the same time-temperature curve by controlling the rate at which the cones come down.

F. H. RIDDLE: It is rather hard for me to agree with what Dr. Schramm has said about the difference in temperature in rapid and slow fire. I have taken the average of cones to about 9 and the difference in temperature on the end point is on an average of 15°, and the variations in temperature of the end point 20–150°, and on 12 cones from 1 to 12, is 33°. These figures make it hard to agree with Dr. Schramm, for we have less variation between cone intervals by practically one-third than we have variations in temperature between the slow and rapid fire.

Careful inspection of the cones after the fire is necessary. If the cones are carefully inspected after the fire as to the amount of seed in them, and particularly those cones which are thoroughly fused, if they form a beautiful colored glass, or if they form a lot of seeds, it is a fine indication of just exactly what kind of firing you have had. Almost invariably, if the lower cones (cones 4 or 5), are below the measuring point, in a steady condition, the clays will be the same way. By adjusting it, there is a good control.

R. F. GELLER: We had prepared one slide here to anticipate a logical question, namely: how close can you come to these temperatures in your own kiln, and what it all means to you practically. In our

work to determine the relative softening points of foreign and American cones, we have followed a certain heating schedule, which entailed heating measurements. So, incidentally we determined also the temperature at which those cones softened under our conditions, which are not so far removed from plant conditions. (Here Mr. Geller presented a slide, showing certain figures covering an entire series of cones from 022 to 34, and explained the relation of these figures one to another with special reference to temperatures.)[1]

F. H. RIDDLE: When I was abroad, they were using cones in France. Cone 1380 would be cone 1.

H. B. HENDERSON: There are two series of cones from France. One is marked with the number of degrees centigrade at which it is supposed to melt, and the other one is numbered in the usual way. There is not much difference in these two series.

[1] See "A Comparison of the Softening Points of some Foreign and American Pyrometric Cones," *This Jour.* p. 748

A COMPARISON OF THE SOFTENING POINTS OF SOME FOREIGN AND AMERICAN PYROMETRIC CONES[1]

By R. F. Geller and E. E. Pressler

ABSTRACT

This paper is a report of results obtained from a study of the softening points of pyrometric cones as made in England, France, Germany, and America. The results are briefly discussed and are also shown photographically so that interested readers can best obtain the specific information they desire from a study of these photographs. The data obtained further indicate that the temperature at which the cones most used in the trade (Nos. 1 to 20) soften can be determined with an accuracy of ± 15°C in laboratory kilns of the gas-fired type, provided good pyrometric equipment is used and reasonable precautions are taken to maintain definite rates of heating. Errors of as much as ± 25° can be expected in the determination of temperatures at which cones less refractory than No. 1 or more refractory than No. 20 soften. In the case of more refractory cones this is due principally to the difficulty of maintaining definite rates of heating while, in the case of the less refractory cones Nos. 022 to 01 inclusive, inaccuracies can be attributed both to difficulty of maintaining definite heating rates and to the sensitiveness of the softening behavior of the cones to furnace atmospheres. This is particularly true of the "red series" (cones 010 to 01) the softening points of which are materially affected by changes of a few per cent in the CO_2 and SO_2 content of furnace gases.

Purpose

The immediate purpose of this investigation was to compare the softening points of representative foreign and American cones under conditions of temperature uniformity and rates of heating known and controlled within limits practical for the average laboratory, but with the determination of the softening points (expressed in temperature) as an incidental factor. It was thought that this information would serve a useful purpose for those investigators who wish to interpret data expressed in cones and contained in European literature.

Cones Used

Cones of American (Standard Pyrometric Cone Co.), English (Central School of Science and Technology), German (Royal Porcelain Co.), and French (Paulene Freres) manufacture were used in this investigation. They were obtained by Edward Orton, Jr., and are believed to represent the cones most used in the particular country represented. Necessary precautions were taken to obtain specimens typical of the product as supplied to the industry.

Scope

The cones investigated ranged from Nos. 022 to 35, inclusive. Temperature readings were taken, but only insofar as necessary

[1] Published by permission of the Director, Bureau of Standards, U. S. Department fo Commerce. Received September 7, 1926.

to maintain a predetermined rate of heating in the immediate vicinity of the cone pat under observation.

Method of Testing

A. Cones 022 to 20 The softening points of cones, ranging from No. 022 to No. 20, were compared in a gas-fired, recuperative type, semimuffle kiln. Figure 1 shows a cross-section of the kiln and the "setting" employed. Natural draft burners are placed at *B* (Fig. 1) and the air for combustion (preheated by the outgoing gases) rises through ports at *A*. The burning gases are drawn up and over the bag walls and then down around and under the muffle, containing the cones, to chamber *C* of the recuperator. Although the flue gases were not analyzed, it is fairly certain that a neutral or oxidizing furnace atmosphere was maintained at all times. The fuel used was carbureted water gas of the following approximate composition, given in per cent: CO_2, 5; O_2, 1; CO, 25; H_2, 34; CH_4, 15; illuminants, 12; H (by difference), 8; the average heating value is 600 B.t.u. per cubic foot.

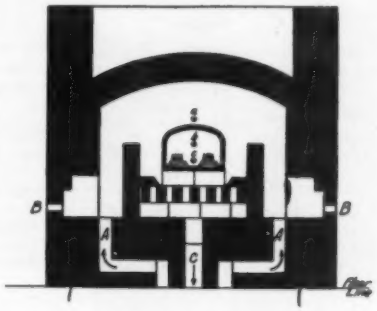

FIG. 1.—Indicates setting of gas-fired, recuperative, downdraft kiln in which the comparative softening points of cones 022 to 20 were determined.

Each plaque carried four cones of one number (English, French, German, and Orton), the height of the plaque, the depth to which the cones were embedded,[1] and the angle of inclination (8°) being maintained practically constant in all cases by means of the gage shown in Fig. 2. In placing the plaques in the muffle they were set level in order that the angle of inclination of all cones might be the same at the beginning of the test.

FIG. 2.—Gage used in setting cones at inclination of approximately 8°.

The cone plaques (mixtures of calcined Al_2O_3 and kaolin) were placed within a secondary muffle (Fig. 1) and all plaques were tested in duplicate. Furthermore, they were so placed that the positions of the respective cones in the one plaque, relative to the distance from

[1] By embedding all cones to the same depth, the results include variations due to differences in the overall lengths of the cones and the consequent variations in the height to which they would normally protrude above the pat.

the muffle wall, were reversed in the duplicate plaque. This was done to reduce the errors caused by temperature gradients within the muffle. Tested duplicate plaques indicated that the error from this source was negligible.

The muffle accommodated ten plaques (representing cones of five numbers). The plaques were placed with the cones in numerical order, the one of lowest number being in front where it could be most conveniently withdrawn at the proper time.

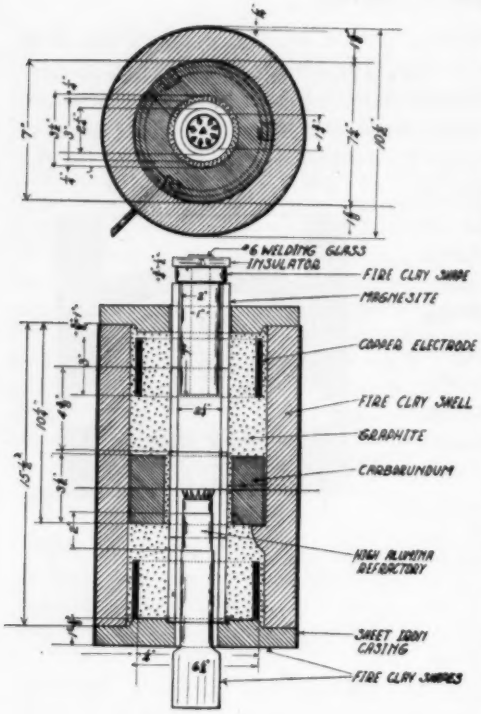

FIG. 3.—Sketch of graphite resistance furnace used in determining the comparative softening points of cones 26 to 35. (For detailed information see paper by W. L. Pendergast, *Jour. Amer. Ceram. Soc.*, **8** [5], 319 (1925).

Rate of Heating The temperature was raised at the rate of 50°C per hour to within 300°C of the temperature (as given by the maker) of the American cone of lowest number in the muffle. Thereupon the rate was changed to 20°C per hour and maintained until the completion of the test.

Each pat was withdrawn as quickly as possible when the tip of the American cone was level with the top of the plaque.

B. Cones 26 to 35 The softening points of the small cones (26 to 35) were determined in the electrically heated furnace shown in Fig. 3.

A plaque of four cones was used, the same precautions of setting being observed as for the larger cones. However, four cones of one number were not placed in one plaque. Instead, American cones were used of lower and higher number than the foreign cone to be tested. In this way a direct comparison of one foreign cone with the American cones of higher and lower softening points is obtained, rather than a direct comparison of the four types of one number.

This procedure was followed because of the relatively large differences found, particularly for cones 26, 27, and 28.[1]

Plaques 4, 5, and 6 (Fig. 15) illustrate the steps required to obtain a desired comparison. The range of American cones was lowered, in this case, until the cone of approximately the same softening point as the French cone was found.

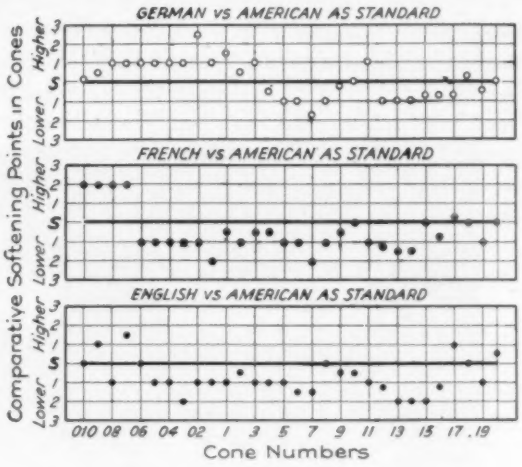
GERMAN vs AMERICAN AS STANDARD
FRENCH vs AMERICAN AS STANDARD
ENGLISH vs AMERICAN AS STANDARD
Comparative Softening Points in Cones
Higher
Lower
010 08 06 04 02 1 3 5 7 9 11 13 15 17 19
Cone Numbers

FIG. 4.—A graphic method of representing comparative softening points.

Rate of Heating The plaques of cones 26 to 35, which were tested in the electrically heated furnace, were precalcined in a gas-fired furnace at 1000°C. Between softening point determinations the temperature of the electric furnace was permitted to drop to approximately 1000°C, a calcined cone plaque was inserted, and the temperature from this point raised according to the rate specified in the A.S.T.M. Standard Method of Test for Softening Point, Serial Designation C 24–20.

Method of Presentation

Several methods of presenting the results were tried in an endeavor to enable the reader to gain quickly a comprehensive idea of their nature.

A. In Fig. 4 a straight line was drawn as a base line representing the softening points of the American cones 010 to 20. A comparison was then obtained by plotting the relative softening points of the German, French, and English cones at the proper intervals (expressed in cones) above or below the line, depending on whether they were more or less refractory than the American cone of corresponding number.

B. Drawings were made of the entire series as shown in Fig. 5.

[1] It would have been advisable to follow such a procedure with the cones of lower number, but this would have required more time than was available for the investigation.

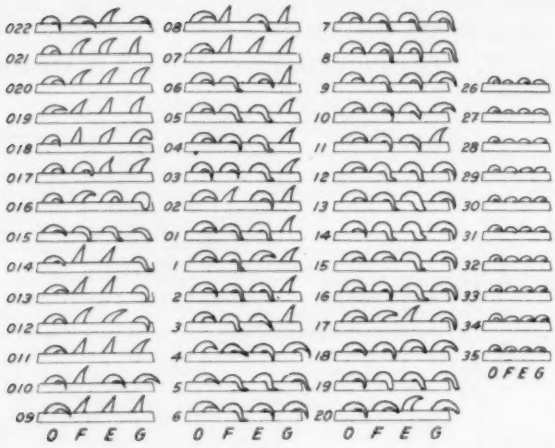

FIG. 5.—The entire series of cones sketched to give a concise representation of comparative softening points.

This is a simple and compact presentation, probably serving its intended purpose. However, it is believed that the user of cones would prefer his own interpretation based on the appearance of the cones themselves. For this reason a photograph of a typical plaque is given for cones of each number.

Results

A. The Hecht Series, Cones 022-011 (Figs. 6 and 7.) The cones of this series are colored as shown in Table I.

TABLE I

COLORS OF CONES BEFORE FIRING

Cone	Orton	German	French	English
022	White	Buff	Buff	Light gray
021	Buff	"	Gray	" "
020	White	Old rose	Yellow	White
019	"	White	White	"
018	"	Old rose	Buff	"
017	"	" "	Yellow	"
016	"	Pale green	White	"
015	"	Buff	"	"
014	"	Old rose	Green	"
013	"	Gray	White	"
012	"	Buff	Buff	"
011	Buff	Old rose	Gray	"

The results for cones 022 to 016 inclusive cannot be compared satisfactorily, due to the "bloating" of many of the foreign cones under the conditions of the tests. For example, English cones 021, 018, and 017 have been bent over by bloating at the base; the same is true of German cones 020, 018, and 017. All of the cones of foreign make from 022 to 017 tended to become vesicular in structure and were extremely sensitive to temperature change, causing them to break into two or

more pieces on removal from the kiln. For photographing it was necessary to glue these pieces in place.

The results may be generalized as follows:

German cones 022, 018, 015, 014, 013, and 012 were from one to two cones softer (*i.e.*, less refractory) than the American, while cones 021, 020, 019, 017, 016, and 011 were one or more cones harder (*i.e.*, more refractory).[1]

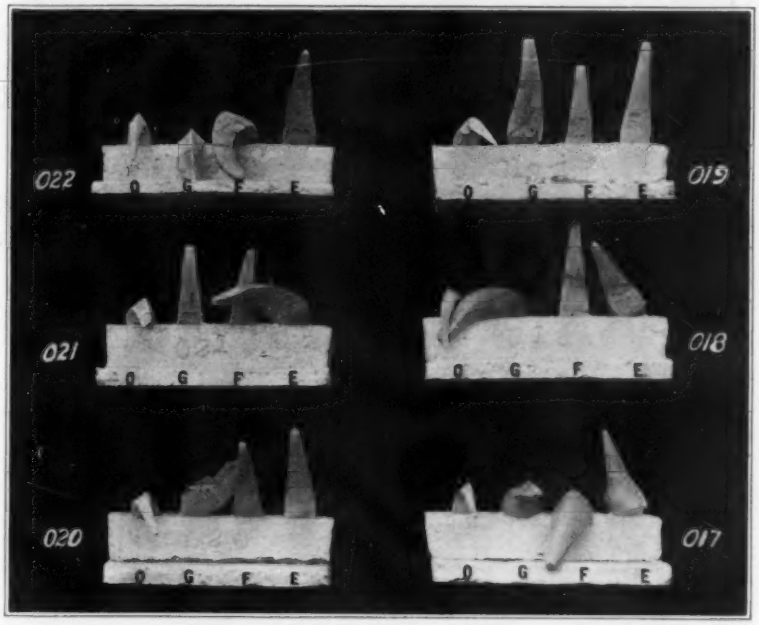

FIG. 6.—Photographs of typical pats showing softening points of cones 022 to 017. O: American; G: German, F: French; E: English.

French cones 022, 017, and 015 were softer by one cone or less, while the balance of the series were harder by, apparently, from 1 to 3 cones.

All of the English cones (with the exception of 015 and 012) were harder, practically paralleling the French series.

B. The Cremer Series, Cones 010-01 (Figs. 8 and 9.) The American and German cones of this

[1] The temperature interval represented by "1 cone" will vary. For data regarding those of the American cones see C. O. Fairchild and M. F. Peters, "Characteristics of Pyrometric Cones," *This Jour.*, p. 701–43. These data will serve to illustrate the differences in cone intervals and also in bending intervals. Furthermore, the cone and bending intervals of the foreign cones may be quite different from those of the American cones and, therefore, "cone differences" can be at best only rough approximations.

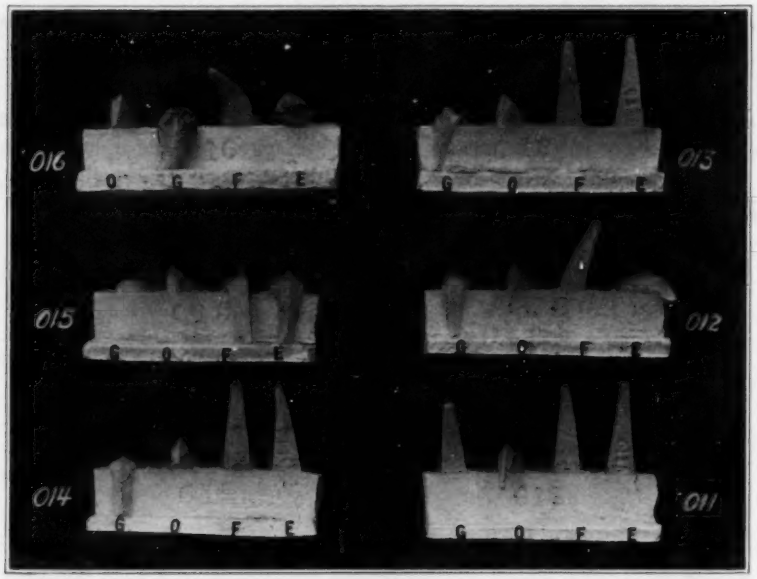

FIG. 7.—Photographs of typical pats showing softening points of cones 016 to 011. O: American; G: German; F: French; E: English.

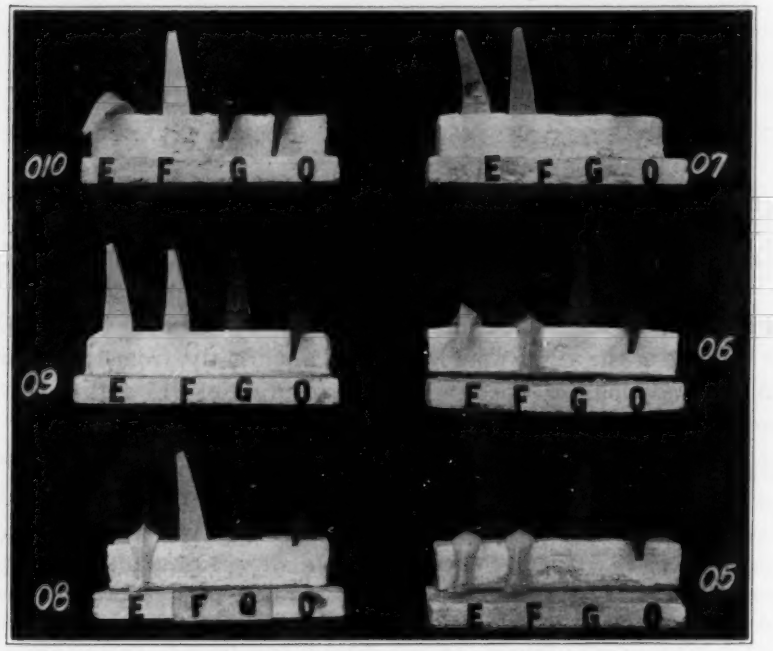

FIG. 8—Photographs of typical pats showing softening points of cones 010 to 05. O: American; G: German; F: French; E: English.

series are red, the French are varicolored, and English are white (Table II).

TABLE II

COLORS OF CONES BEFORE FIRING

Cone	Orton	German	French	English
010	Red	Red	White	White
09	"	"	"	Gray
08	"	"	Old rose	White
07	"	"	Green	"
06	"	"	Old rose	"
05	"	"	Green	"
04	"	"	White	"
03	"	"	Green	"
02	"	"	Lavender	"
01	"	"	Green	"
1	"	"	Light gray	"

With the exception of English and French cones 04, 03, 02, and 01 (Fig. 9), this series softened and bent normally. Each of these four

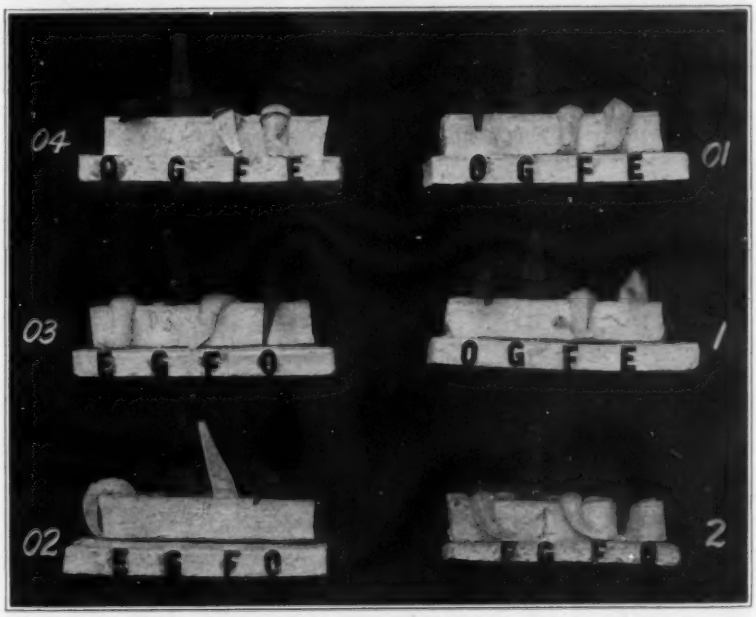

FIG. 9.—Photographs of typical pats showing softening points of cones 04 to 2. O: American; G: German; F: French; E: English.

cones formed a refractory "skin" which had a tendency to hold the cone upright after the interior had become quite soft. It should be noted that American cones 010, 09, and 03 passed the "end point" (described at the end of part A under Method of Testing, p. 745) while being removed from the muffle.

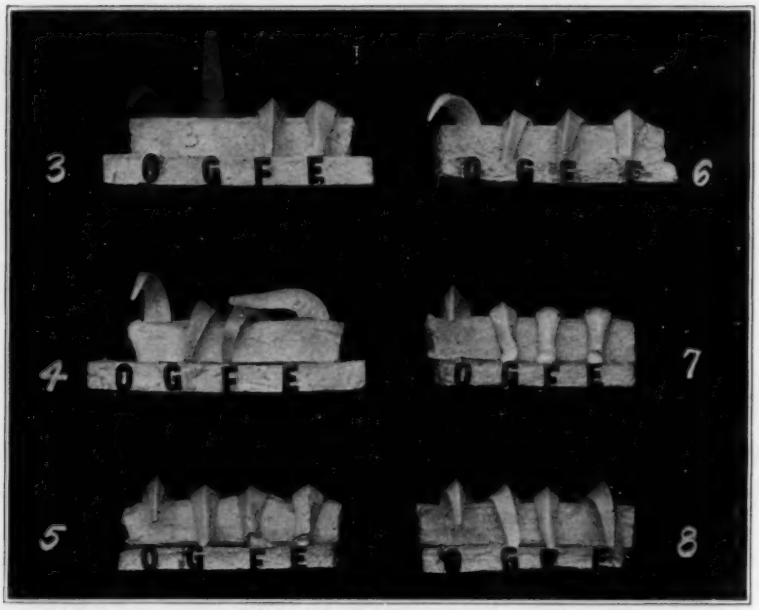

FIG. 10.—Photographs of typical pats showing softening points of cones 3 to 8. O: American; G: German; F: French; E: English.

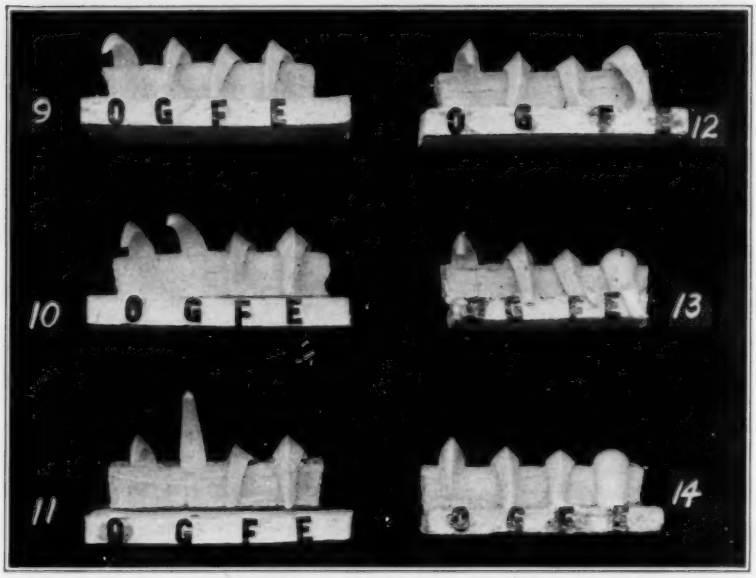

FIG. 11.—Photographs of typical pats showing softening points of cones 9 to 14. O: American; G: German; F: French; E: English.

German cone 010 was approximately the same as the American cone of the same number, but all the others of the series were harder by what appeared to be at least one cone interval.

French cones 010, 09, 08, and 07 are harder than the American by one to two cones. At this point a marked change must have been made in the composition of one of the series, for the balance of the French cones are *softer* than the American by at least one cone.

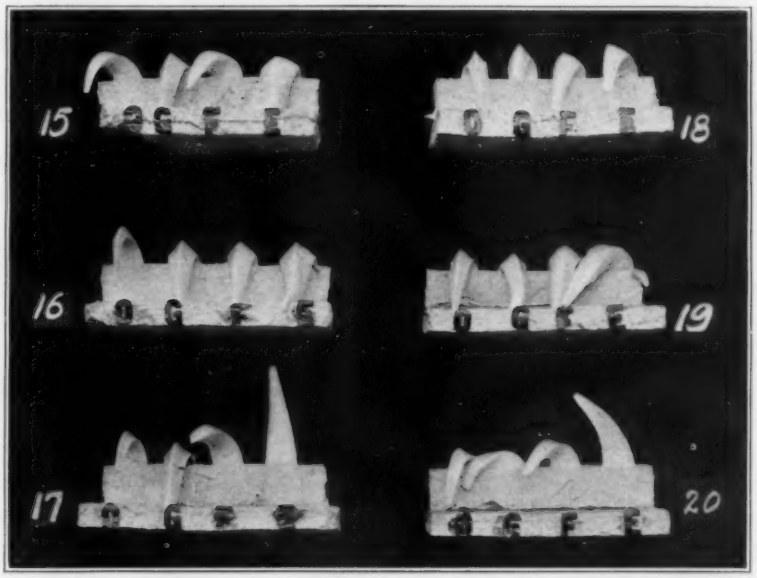

FIG. 12.—Photographs of typical pats showing softening points of cones 15 to 20. O: American; G: German; F: French; E: English.

The behavior of the English cones 010 to 06 inclusive is somewhat erratic as compared with the American; cones 010 and 06 are approximately the same, 09 is at least one cone harder, 08 is about one cone softer, and 07 about two cones harder. For the balance of the series they are apparently about one cone softer.

C. The Seger Series, Cones 1 to 20, Inclusive (Figs. 9 to 12.) The cones of this series are colored as shown in Table III. After fusion all the cones are practically white with the exception of the American and German cones 1, 2, and 3, which are reddish brown, and the French cone 4 which is light blue.

(Note: while French cone 02 is still standing, it is believed that this is due to the "skin" formation previously mentioned.)

TABLE III

COLORS OF CONES BEFORE FIRING

Cone	Orton	German	French	English
1	Red	Red	Light gray	White
2	"	Buff	Gray	"
3	"	Red	Buff	Gray
4	White	Gray	Blue	White
5	"	Buff	White	"
6	"	"	"	"
7	"	"	"	"
8	"	"	Green	"
9	"	Gray	"	"
10	"	White	"	"
11	"	"	White	Gray
12	"	Buff	Gray	White
13	"	Light gray	Buff	"
14	"	Buff	Green	"
15	"	Light gray	Old rose	"
16	"	" "	" "	Gray
17	"	White	Green	White
18	"	Buff	"	"
19	"	White	Buff	"
20	"	"	White	Gray

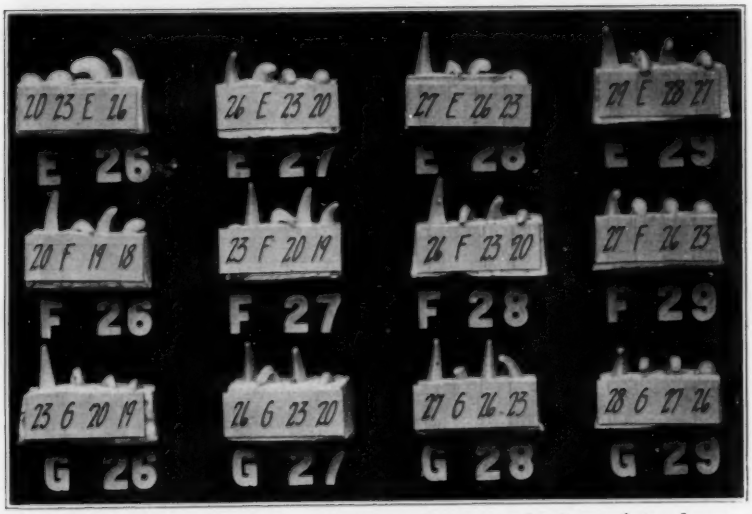

FIG. 13.—Photographs of typical pats showing softening points of cones 26 to 29. G: German; F: French; E: English; the cones referred to on the pats by number are American cones.

English cones 10 to 19 inclusive were found to bloat and blister, this being particularly true of numbers 13, 14, and 15. All others softened and bent normally; the peculiar behavior of English cone 4

in the plaque photographed is not typical. American cones 2, 8, 14, 18, 19, and 20 had passed the end point before they could be removed; this was due to the comparatively rapid bending of these cones with constantly rising temperature, and to the effects of the slight jarring incidental to their removal.

German cones 1, 2, and 3 are about one cone harder than the American, cones 4 to 8 from one-half to one and one-half cones softer, 9 and 10 appear to be practically the same, cone 11 is harder, cones 12 to 17 are consistently softer by about one cone and 18, 19, and 20 are the same as the American.

D. The High Temperature Series, Cones 26 to 35[1] (Figs. 13 to 15.) All the cones in this series are white or a very light gray and all of the cones of foreign make are less refractory than the American, and markedly so in the case of cones 26 to 30.

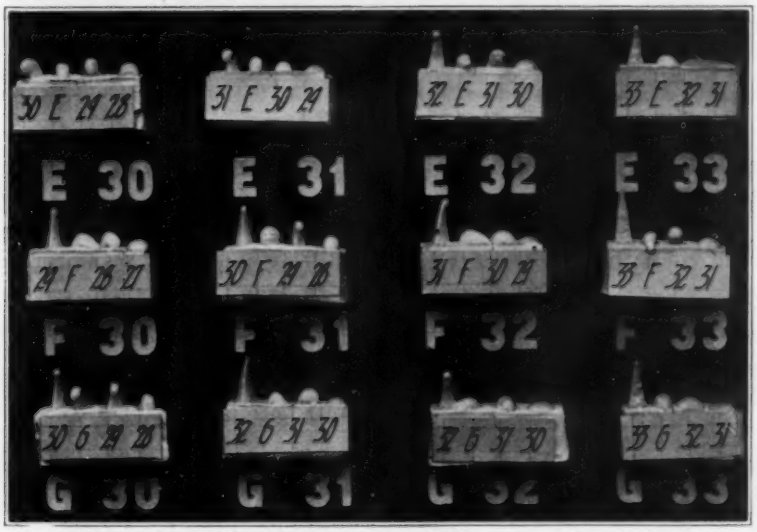

FIG. 14.—Photographs of typical pats showing softening points of cones 30 to 33. G: German; F: French; E: English; the cones referred to on the pats by number are American cones.

The greatest inconsistency noticed in the investigation was in the behavior of French cone 26. This cone is not only much softer than French cone 20 (plaques 2 and 3, Fig. 15), but it apparently has no definite softening point. In Fig. 13 it appears slightly softer than American cone 18, in plaque 2 (Fig. 15) it appears equal to the American

[1] The entire series is composed of cones 26 to 42, inclusive; cone 35 was the highest numbered cone investigated.

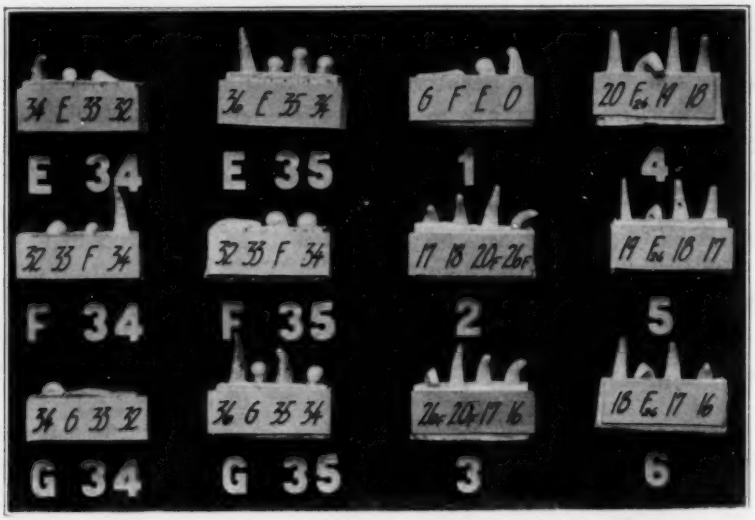

FIG. 15.—Photographs of typical pats showing softening points of cones 34 and 35. G: German; F: French; E: English; the cones referred to on the pats by number are American cones.

For comparison, cone 34 of each brand is shown in pat No. 1.

Pats 2 and 3 show French small cone 26 compared with French large cone 20 (cut down to the size of the small cone) and American cones 16, 17, and 18.

Pats 4, 5, and 6 illustrate the method used in determining the comparative softening points of the foreign cones 26 to 35.

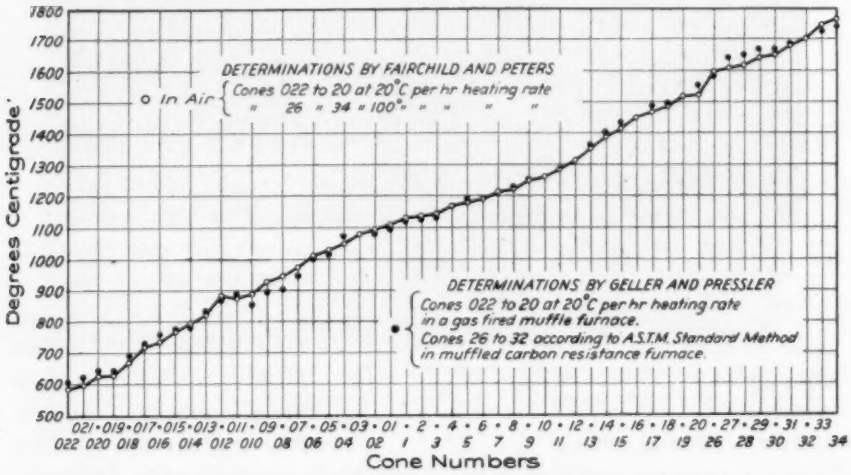
Degrees Centigrade
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
DETERMINATIONS BY FAIRCHILD AND PETERS
o In Air { Cones 022 to 20 at 20°C per hr heating rate
" 26 " 34 " 100° " " " "
DETERMINATIONS BY GELLER AND PRESSLER
Cones 022 to 20 at 20°C per hr heating rate in a gas fired muffle furnace.
Cones 26 to 32 according to A.S.T.M. Standard Method in muffled carbon resistance furnace.
021 019 017 015 013 011 09 07 05 03 01 2 4 6 8 10 12 14 16 18 20 27 29 31 33
022 020 018 016 014 012 010 08 06 04 02 1 3 5 7 9 11 13 15 17 19 26 28 30 32 34
Cone Numbers

FIG. 16.—The temperatures at which American cones reached their end point, as determined in this investigation, compared with the more accurate determinations of Fairchild and Peters. (*This Jour.*, pp. 701-43.)

cone 17, and in plaques 3 and 6 (Fig. 15) it appears slightly softer than American cone 16. For convenience the results of this series are summarized in Table IV.

TABLE IV

The numbers in columns 2, 3, and 4 designate the American cone or cones estimated to be nearest in softening point to the foreign cone indicated in name by the column headings, and in number by column one.

(1) Cone	(2) German	(3) French	(4) English
26	20–23	(*a*)	23–26
27	20–23	18	23–26
28	23–26	20	26
29	27	26–27	27
30	29	27–28	28
31	30–31	28	30–31
32	31	29–30	31
33	32–33	31–32	32
34	33–34	32–33	33
35 (*b*)	34	34	34

(*a*) Discussed in Text.

(*b*) Results are not considered satisfactory, due to the "beading" of the cone, but are given as rough approximations.

Temperature and Time vs. Softening Point

The results shown graphically in Fig. 16 were recorded as a part of the investigation described above and are compared with determinations made under accurately controlled conditions.[1]

The data indicate that the temperature at which the cones most used in the trade (Nos. 1 to 20) soften can be determined with an accuracy of ± 15°C in laboratory kilns of the gas-fired type, provided good pyrometric equipment is used and reasonable precautions are taken to maintain definite rates of heating. Errors of as much as ± 25° can be expected in the determination of temperatures at which cones less refractory than No. 1 or more refractory than No. 20 soften. In the case of the more refractory cones this is due not only to greater errors of temperature measurements but also to the difficulty of maintaining definite rates of heating, while, in the case of the less refractory cones (Nos. 022 to 01 inclusive), inaccuracies can be attributed both to difficulty of maintaining definite heating rates and to the sensitiveness of the cones to furnace atmospheres. This is particularly true of the "red series" (cones 010 to 01) the softening points of which are materially affected by changes of a few per cent in the CO_2 and SO_2 content of furnace gases.

[1] See Fairchild and Peters.

SILICON-CARBIDE REFRACTORIES FOR WATER-GAS GENERATORS[1]

By M. L. Hartmann[2] and John A. King[3]

ABSTRACT

A discussion of the problems involved in water-gas generator refractories is given and the steps in the development leading to the present highly satisfactory silicon-carbide air-ventilated Bernitz type blocks are given. Actual operating costs of typical installations are given. It is shown that generator capacities have been increased as much as 50% and fuel reductions have been so large that a real saving in net operating costs has resulted from the installation of this type of lining. Many generators have now been lined and economically operated with air ventilated silicon-carbide blocks.

The recognition of the cause of failure of refractories is frequently the longest step toward solution of the difficulty. So it has been with water-gas generators, although the complete solution was not attained in a single step.

Operators of water-gas generators have for years been struggling with clay linings. They have accepted frequent relining as a necessary evil, continually changing and experimenting in the hope of finding a miraculous clay or silica brick which would be almost permanent. To date no low (first) cost refractory materials have been found which give continuous and satisfactory service life.

How does a water-gas generator lining fail? Every observing operator knows that the usual clay linings are broken up by the incessant barring off of clinkers and ash which have fused to the clay blocks. Some grades of coal are worse than others. It is common practice to "bar down" generators twice a day, requiring three men from thirty to ninety minutes with a heavy bar rigged on a chain fall. The men must work from the top of the open generator, the heat is intense, the work heavy, and workmen cannot be expected to be gentle with the lining. In hammering off these clinkers, large pieces of the brickwork are broken out with the result that a good clay lining will last only about 1000 gas-making hours.

One of the first and most successful applications of silicon-carbide refractories was in boiler furnaces where their success was largely due to non-adherence of the clinker to the Carborundum. Similar results, logically, were expected in gas-generator linings. This proved to be true, but other factors offset this advantage to some extent, and the development was slow.

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[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb. 1926. (Refractories Division.) Received Jan. 18, 1926.

[2] Director of Research, The Carborundum Co., Niagara Falls, N. Y.

[3] District Refractory Representative, The Carborundum Company, Worcester, Mass.

Plain Silicon-Carbide Linings

One of the early installations was made in a 9-foot water-gas generator set at New Bedford, Mass., in 1918. The blocks were of the type formerly manufactured by the Didier March Company, consisting of a thin silicon-carbide section dovetailed into heavier clay block. Although lasting only a few months, this test proved that clinker trouble could practically be eliminated. No longer life was obtained than with the clay alone due to the mechanical structure of the blocks. The veneer of silicon carbide began to break off and once started, adjacent surfaces peeled off rapidly. This type of block construction was abandoned.

Another installation in the same plant consisted of 4½ inch thickness of recrystallized Carborundum bricks known as "Refrax." These bricks are entirely Carborundum, with no bonding material, the bricks being held together by the recrystallization of the silicon carbide in an electric furnace. "Refrax" brick are extremely refractory, not melting even up to a temperature of about 4000°F, at which temperature Carborundum decomposes. The bricks are, however, somewhat porous and allow gas penetration.

This lining of circle bricks of "Refrax" material was installed in an 11-foot UGI set at New Bedford in 1920. The lining, 4½ inches thick, extended to a point of 5 feet above the grates. Backing the Carborundum was 9½ inches of clay brick followed by 2½ inches of diatomaceous earth brick. The set was started in March, 1921, and after eight months continuous operation, the vertical seams in the steel shell of the generator opened up due to the growth of the lining. Temporary repairs were made and the set was operated until March 28, 1922, at which time it was shut down for relining. The "Refrax" lining had lasted 4123 gas-making hours. Clinker troubles were practically nil; the work required to clean the clinkers off was insignificant in comparison with the work of cleaning off of clay blocks. The swelling of the lining was the direct cause of the failure.

Results on this lining seemed to warrant further trial and in April, 1922, another lining made of "Carbofrax" brick was installed. "Carbofrax" is the trade name for bonded silicon-carbide bricks and these were especially made to withstand penetration of gases and consequent oxidation. This installation was very successful, lasting 6687 gas-making hours. The lining gradually wore down until it was too thin for further patching. Another lining of Carbofrax was installed in November, 1923, and this lining is still in use. Up to the present time it has given a total of 6900 gas-making hours.

Walter M. Russell of the Massachusetts Lighting Co., writing as chairman of the Sub-Committee on Refractories of the American

Gas Association[1] reports further in regard to these plain generator linings:

> We find that about a year after a Carborundum lining is installed the side clinker begins to stick tighter to the lining due to small cracks in the lining brick and cement between brick coming out, giving the clinker a better chance to stick and so taking more time to break down side clinker but not so much time as required with a clay lining. Before the lining gets to this condition two men with a light bar can break off the side clinker in about 15 minutes.
>
> The Carborundum arches and jamb brick at fire doors we find require more patching than the lining due to striking of clinker bars against them and using the edge of the jamb as a fulcrum for clinker bars when the set is being clinkered.
>
> We also find it necessary to leave some clinker at the fire doors to keep the doors cool as due to the shape and size of the door jamb brick the Sil-O-Cel between these brick and the shell is much less than at other points, which with the greater conductivity of the Carborundum brick will cause the door frames to get red hot if no clinker is left in the doors.

The New Bedford Gas Company, however, considered the installation as a whole to be very satisfactory, for not only did it save money on repairs, but in their case saved them the investment of an additional water-gas set, which would have been necessary had they been required to use the clay blocks which necessitated relining shutdowns after 1000 gas-making hours.

Similar results were obtained at an installation in Springfield, Mass., where a life of approximately 7,000 hours was given by the Carbofrax lining.

In another installation the clinker costs were reduced as much as 40% and the labor cost reduced 20% due to the decreased number of shutdowns. It has also been observed that the longer life of the generator lining has directly resulted in the longer life of the carbureter and the checker brick. Shutdowns for repairs had formerly been determined by the life of the generator lining, but with Carbofrax lining it is now determined by the condition of the checker brick, and results obtained from the machine. One user has estimated that in the operation for the first ten months' period the lining has paid for itself and is in condition for at least three or four months more of operation. This means a very considerable saving.

On these latter installations allowance has been made in the outer shell to care for the growth or swelling of the silicon-carbide lining. Between the outer shell and the fire brick, a 2-inch space filled with asbestos has been provided, and between the fire brick and the silicon-carbide lining a 2-inch space filled with blue clay which allows for the later expansion of the silicon-carbide lining.

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[1] Report of Water Gas Committee, 1925 Convention, American Gas Association.

Linings of these types have not been, in general, considered wholly satisfactory in performance or life, and are no longer recommended since the perfection of the Bernitz block lining.

Bernitz Block Linings

The newest and most successful development in this field is the Bernitz block lining. For a number of years the Bernitz Furnace Appliance Company has marketed an air-cooled block to prevent clinker adhesion. These had been extensively used in boiler furnaces and it was natural to expect them to prevent the same difficulty in water-gas generators.

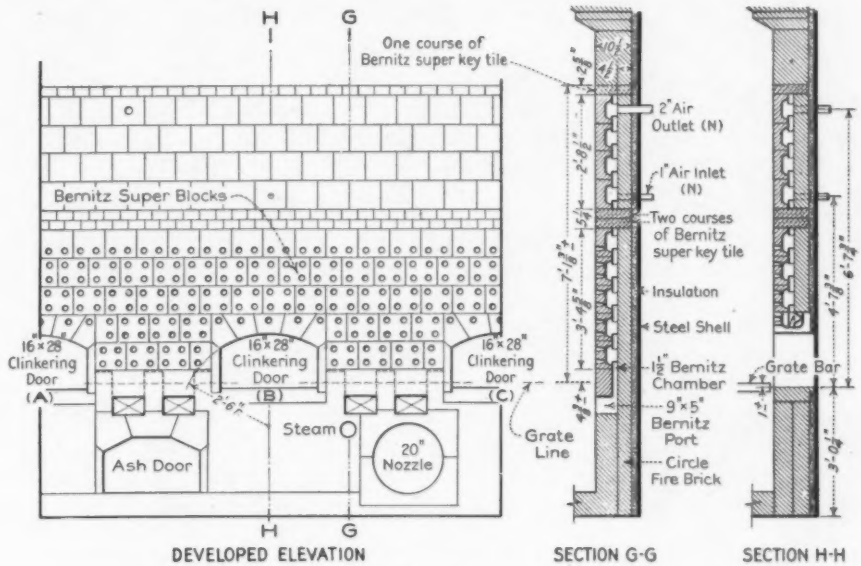

FIG. 1.

In May, 1922, an installation of fireclay Bernitz block was made in an 8-foot set at Gloucester, Mass. This trial, however, was not successful, the clay disintegrating by spalling. There was no apparent advantage in using the air-cooling system with clay-generator linings.

A big step in advance was made when Bernitz blocks made of Carbofrax were adopted for preventing clinker adhesion and slag erosion in boiler furnace practice where their almost universal success naturally lead to their trial in water-gas generators.

A typical Bernitz block is shown in Figs. 2a and 2b. The hollow block shape is pierced on the side adjacent to the fire with a number of cone-shaped holes larger at the face and smaller at the back. When used as a lining for water-gas generators these holes permit the introduction of the air or steam at various points in the fire. The great mechanical

strength of Carbofrax at high temperatures, its lack of chemical activity in contact with chilled or viscous slags, and the high thermal conductivity which permits sufficient cooling of the working surface to prevent reaction with and adherence of slags, are the reasons for its remarkable success in water-gas linings.

A number of successful installations have been made during the past two years. Certain improvements and corrections have been made from each installation to the next until a very satisfactory type of installation has been developed.

An account of some of the salient features of several installations are abstracted freely from Mr. Russell's report to the Gas Association.

The Gloucester (Mass.) Gas Light Company installed five courses of Carborundum Bernitz blocks, 14 inches long by 8 inches high, each containing six holes in an 8-foot Gas Machinery set. In order to prevent injury from expansion, a cored block was made to a careful design so that any expansion would be taken up by the arch construction of the block. No trouble was encountered with this (or any other) Carborundum Bernitz block installation. There was no tendency whatever for clinker adherence and no deterioration from spalling or wear. This set of blocks ran from June, 1923, to December, 1924, making gas for about 2600 hours. Most of the blocks were in first class condition. The clay lining above the Bernitz blocks was badly broken up by the adherence of clinker there and some Bernitz block had been broken in the process. To overcome this, two rows of blank Bernitz blocks (having no holes) were installed in October, 1923, and this alteration completely stopped clinker troubles. During this period door jambs and arches of clay wore out rapidly, but were subsequently replaced with Bernitz designed blocks and troubles around door jambs and arches ceased. Many of the blocks were usable even after shutting down the machine. Fuel consumption was decreased, output per square foot was increased 20%, clinkering time cut in half and labor greatly reduced.

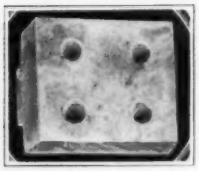

FIG. 2a.

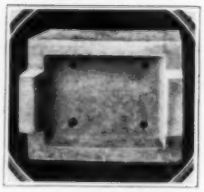

FIG. 2b.

At the Spencer (Mass.) Gas Company a new 5-foot set was equipped with five courses of Bernitz Carborundum blocks and two courses of blank Carborundum blocks. During the first 15 months' operation the clay blocks above the Carborundum were replaced twice. Later, the Carborundum lining was carried to the crown. Capacity of the machine is 20% greater than is expected from this type. There has been no clinker trouble in 15 months' operation.

Typical of the improved later installations is the one at Arlington, Mass., which was made in March, 1924, incorporating all the modifications brought out in the two years' previous experience. This set has now been in operation over 8000 gas-making hours. In this type installation, flues are formed between the inside and outside linings. When the air is blown into the ash pit, a large proportion of it, instead of going through the grates, passes up through the flues behind the Carbofrax lining and enters the fire through the holes in the block. This gives a perfect distribution of the air to the fire and overcomes the difficulty of clinker formation at the grate. During the run, steam passes through these holes giving a very thorough distribution with more regular and improved gas-making results. On the down run the blue gas passes out through these blocks. Due to the distribution of the air the combustion is less intense in any one location and the tendency is to form soft or unfused clinkers. The relatively cool air coming through the ports and blocks chills the clinker and prevents it from adhering to the side walls. The steam also tends to break and soften the clinker and causes it to shrink away from the lining. Figure 3 shows the Carborundum Bernitz lining at Arlington, Mass., after it had operated 4800 gas-making hours. Figure 1 is a close up view of the same lining showing the various kinds of bocks used. Figure 2 is a typical detail drawing of the Bernitz lining for a 9 foot set.

FIG. 3.

In one of the early trials silica blocks were used just above the top of Bernitz blocks. It was found that the heat and overcharging of the generator causes considerable clinker to form above the Carbofrax lining. In later installations this trouble was eliminated by the use of two or more air-cooled blocks without port openings. One of the many advantages of keeping the walls free from clinkers is the possibility of getting a longer run, thus increasing the yield and the efficiency of the set. For example, in one generator on a test run, over 24-hour periods, the output of the set increased 50%. There was also a great saving in labor and a reduction of fuel from 3 to 10% and of oil from 2 to 5%.

Accurate data has been kept on the costs of the lining at Arlington, Mass. This lining has now out-run eight clay linings. Inasmuch as it costs about $50 to shut down and start the set, appreciable saving has been made in this one item alone. In addition there is a labor saving

in the "barring down" amounting to $750 in the life of linings. A comparison of the cost of Carborundum Bernitz lining as compared with clay is as follows:

Cost of Carborundum Bernitz lining		$1800
7 repairs to ordinary clay lining		1575
Increase in first cost of Bernitz lining		$ 225
Saving in clinker, labor 30 minutes per day, 6 men, 400 days = 1200 hrs.	$750	
Saving in shutdown	300	1050
Total saving in favor of Bernitz lining		$ 825

Some other illustrative causes of the marked economies which have been actually secured by the use of the silicon-carbide Bernitz blocks, not only in lining costs but actual fuel saving, may be of interest.

At Glassboro, New Jersey, a Gas Machinery Company Generator 8 ft. 6 in. outside diameter was lined with silicon-carbide blocks of the Bernitz type. The average amount of fuel required per 1000 cu. ft. of gas was reduced from 27½ lbs. to 25 lbs. The amount of air required was materially reduced, and the air pressure required for successful operation was dropped about 20%. This plant has since installed a second lining in its other 8 ft. 6 in. generator.

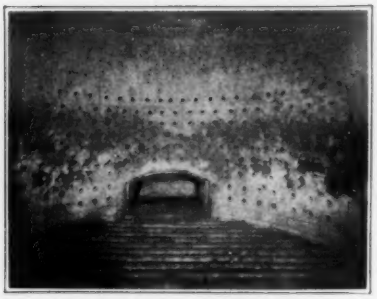

FIG. 4.

In another installation (at Paulsboro, N. J.) in a 5-foot generator, fuel has been reduced from 40 to 28 lbs. per 1000 cu. ft. of gas and the overall capacity has been increased about 30%. After 1600 operating hours the generator lining at this plant was in apparently as good condition as when originally installed. The shutdown was required because of the failure of the carburetor checkering. This plant has since installed its second lining in a 4 ft. 6 in. generator.

Practically identical economies were secured at another plant (Cumberland Gas Co., Millville, N. J.) in a 6-foot Gas Machinery Co. Generator. Gas was actually produced at a net saving of 30% over the best previous records.

The Wilmington Gas Company is now operating an eleven foot U.G.I. generator lined with Bernitz Carbofrax blocks. This generator has been in operation for 3000 hours and shows no trace of wear. The best previous record with clay linings was 900 hours. It has been

possible to operate the generator for 24-hour periods with a single cleaning. The longest time required to clean the generator has been 70 minutes.

Due to operating conditions, differences in fuel, etc., saving in clinker-removing labor is not of interest in certain cases. However, the cost of the lining is returned several times over in the economies in consumption of materials. Not only has a saving in generator fuel been shown, but also in boiler fuel and in oil in many cases. The saving in oil is due to the fact that a better grade of blue gas is made, and requires less oil gas addition. The saving in boiler fuel is due to the fact that a lower pressure is required in Bernitz constructions than when all the gases are put through the grate. There are installations in which the fuel saving is greater than the saving in labor.

An important advantage which may be overlooked is a very large increase in capacity which has been universal when gas generators have changed to the Bernitz construction. While the first cost in comparison with a clay lining is always high, there has been no report that the saving did not justify the original expenditure and all who have used this have been enthusiastic about it.

A total of thirty-one Bernitż type units are now in operation. Twenty of these were installed in the year 1925. This type of lining for water-gas generators has passed the experimental stage and is a proven success.

THE CARBORUNDUM CO.
NIAGARA FALLS, N. Y.

THE HARPER ELECTRIC KILN[1]

By Francis A. J. FitzGerald

ABSTRACT

A description of the development of an electric kiln for porcelain and of the construction of an experimental commercial unit for firing biscuit ware at the works of the Buffalo Pottery Co. The kiln is of the continuous tunnel type and in the course of its development has been used for firing porcelain at temperatures as high as 1500°C (2750°F).

Several years ago the late John L. Harper, Chief Engineer of the Niagara Falls Power Company, conceived the idea of making an electric kiln for the heat treatment of porcelain. Originally he proposed to build this kiln in the form of two tunnels of considerable length heated in the center part by means of electrical resistors. The cars were to pass through the tunnels in opposite directions, in order that the heat generated by the kiln would be used to the greatest advantage. Harper knew that the periodic kiln, usually employed for the firing of porcelain, was thermally very inefficient, so that, in spite of the relatively high cost per unit of heat generated electrically, it would be possible to compete with fuel, because the electric furnace permitted of a more efficient design, particularly if the twin tunnel were used.

He also saw that in the electric furnace he could obtain a more perfect control of temperature and atmosphere and could thus make a better porcelain with lower kiln losses.

After making various experiments on electric furnaces Harper asked FitzGerald to coöperate with him in the development of the electric kiln and preliminary experiments were begun in 1909. These though carried out on a small scale were so satisfactory that they led to the preparation of plans for the building of a larger furnace. In 1923, arrangements were made with the Champion Porcelain Company of Detroit for experiments on a fairly large scale with the Harper kiln at the FitzGerald Laboratories.

Except in special processes, where high temperatures are with difficulty obtained with fuel, the cost of heating by electric current is bound to be much higher than with fuel. The cost per heat unit is, in general, much higher when generated by the electric current than by fuel; but where high temperatures are required it is sometimes possible to use the electrically generated heat with so much greater economy that, though the cost per heat unit is much higher, the total number of heat units used is so much less that the heating cost is less.

Another important consideration in comparing electric with fuel heat is that the use of the former permits of other economies which more than offset the higher cost of the unit of electric heat.

[1] Received September 1, 1926.

In the early days of the electric furnace for steel making it was freely predicted that electricity could never be used for steel making except in the manufacture of crucible steel, because the cost of heating electrically would be so enormously greater than the cost of heating by fuel. This prediction has not been fulfilled because of the other offsetting advantages.

An analogous condition may be found in the pottery industry, because the ordinary periodic kiln, like the crucible furnace for steel, is thermally a very inefficient apparatus. It is quite possible, indeed highly probable, that with sufficiently cheap electric power the cost of the heat units in the electrically heated kiln might not be more; but where electric power is not cheap or where the electric tunnel kiln has to compete with an efficient fuel-fired tunnel kiln, it seems probable that the cost of the heat energy generated electrically would be higher than that obtained from fuel. As it is in crucible steel melting there seem to be other advantages in the electric kiln which would more than offset the higher cost of heat obtained electrically.

Experimental Kiln

It was a consideration of this kind which led to the abandonment for the time being of Mr. Harper's original plan of using the two-tunnel kiln with cars traveling in opposite directions. It was felt that the greater difficulties of construction in the two-tunnel kiln would offset the thermal economies which might be reached by it. Accordingly the experimental kiln consisted of a single tunnel 40 feet long. Figure 1 shows the central part of the kiln, including the electrically heated hot zone. Experimental work with this kiln was carried on for over a year and after this a larger kiln was constructed at the works of the Buffalo Pottery Company, Buffalo, N. Y. (Fig. 2.)

FIG. 1.

Kiln at Buffalo Pottery

The Kiln The drawing on Fig. 3 shows a plan, elevation, and two cross-sections of a semicommercial kiln designed for firing biscuit ware in the Buffalo Pottery Company's plant in Buffalo, N. Y. The kiln has a single tunnel 68 feet long with air locks 3 feet

5 inches long at each end. Nearly at the center of the tunnel is situated what is known as the hot zone, a transverse cross-section of which is shown. This zone is approximately 19 feet long. The entrance end of the tunnel, known as the preheating chamber, is about 24 feet long, the exit end, where the cars and their contents cool after leaving the hot zone, is approximately 25 feet long. Parallel to the kiln is a return track for the cars. At each end of the kiln is a transfer truck, running on tracks, which carries a single car from the return track to the entrance air lock or from the exit air lock to the return track. The tracks in the kiln are made of pipes through which water is circulated for cooling. The train of cars is pushed through the kiln by means of a ram driven by an electric motor through reduction gearing.

FIG. 2.

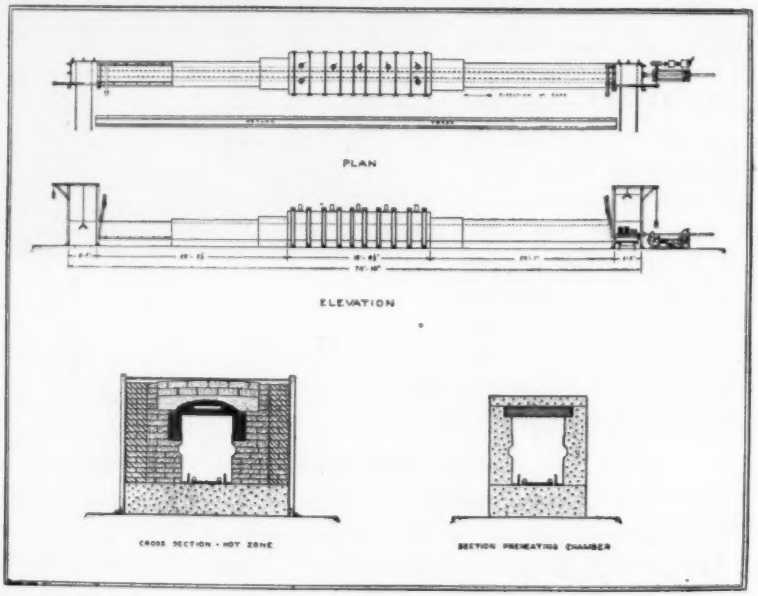

FIG. 3.

Metallic Resistors in Preheating Zone The preheating chamber carries on the side walls and roof metallic resistors, not shown in the drawing of this section in Fig. 3. Figure 4 is a photograph showing the disposal of the metallic resistor on one of the side walls of the preheating chamber. With these resistors the temperature of the ware on the cars can be raised to 900°C before a car enters the hot zone.

Graphite Resistors in Hot Zone The resistor in the hot zone is built up of grids made by cutting blind slots in alternate sides of Acheson graphite electrodes 1½ x 11 x 48 inches. The resistor is enclosed in the resistor chamber above the tunnel, as shown in the cross-section of the hot zone, separated from the tunnel by a refractory septum which forms the floor of the resistor chamber and the roof of the tunnel's hot zone. The resistor is made of four of these grids connected in series. The resistor chamber is constructed of a silicon-carbide refractory and is supported on silicon-carbide bricks which form the side walls of the tunnel in the hot zone.

FIG. 4.

The electric current is brought to the resistor by means of a pair of graphite terminals at each end of the resistor chamber, passing through its roof, as shown in the plan, Fig. 3. The three intermediate terminals shown in the plan make contact with the connectors between the four graphite grids composing the resistor.

Insulation of Preheating and Hot Zone Care is taken in the construction of the kiln to provide the best possible heat insulation for the preheating chamber and the hot zone; but that part of the tunnel which forms the exit from the hot zone is not heat insulated any more than is necessary to prevent too rapid cooling of the ware.

Transformers The electrical equipment to supply current to the resistors consists of two transformer units, one used for the preheating metallic resistor, the other for the hot zone resistor. The preheating transformer unit has a capacity of 30 kilowatts and its secondary winding has taps which permit of varying the voltage at the terminals of the metallic resistor in the preheating chamber. There are two reasons for providing means for varying this voltage: first, because this particular furnace was designed for experimental purposes and it was not known before it was put into use just how much

of the total power of the heating circuit should be used in the preheating chamber in order to get the best results; second, it was necessary to provide means for regulating secondary voltage of the transformer in case there were changes in the voltage of the power line connected to the primary of the transformer.

The transformer supplying current to the hot zone resistor has a capacity of 60 kilovolt amperes and by means of an induction regulator the voltage of the secondary circuit, going to the hot zone resistors, may be varied between wide limits.

Since it is necessary to maintain within narrow limits the power in the hot zone a regulator is provided which automatically operates a motor connected to the induction regulator, causing that apparatus to increase or decrease the voltage of the current supplied to the transformer so as to maintain the power in the resistor at whatever wattage is desired. This regulator actually maintains the wattage within plus or minus 0.5 kilowatt of the power for which it is set.

The Cars Figure 5 is from a photograph showing the construction of the cars on which the ware is carried through the kiln. The framework of the car is of cast iron, the wheel shafts running in Acheson graphite bearings so that they are self-lubricating. The iron aprons on the sides of the framework run in the sand seal, indicated in the two sectional views of Fig. 3. A hopper used to feed sand into the sand seal is seen in the side wall of the kiln just to the left of the airlock door in Fig. 2. The first layer of bricks laid on the car frame are heat insulators made of Sil-O-Cel. Above these is a course of fireclay splits arranged so as to form a radiation baffle running in the horizontal slots of the kiln side walls, as shown in the sectional views of Fig. 3. The next course is made of a special heat insulating brick made by the Carborundum Company and known as insulfrax bricks. These have excellent insulating properties and at the same time are highly refractory being quite unaffected for temperatures at least as high as 1300°C. Finally, on top of the car is a molded slab of silicon carbide, a refractory that is at the same time a relatively good conductor of heat. It will be observed that the Sil-O-Cel and insulfrax bricks are bevelled so as to form a radiation baffle, interlocking with the next car.

FIG. 5.

In Fig. 5 the car is shown loaded with setter plates, and when biscuit ware is firing it is loaded on the car in a similar way, no saggers

being used. The object of making the top slab of the car of good heat-conducting material is to equalize the temperature over the bottom of the bungs as much as possible.

Heat Distribution in Kiln In describing the hot zone of the kiln it was mentioned that the side walls supporting the recrystallized silicon-carbide septum plate in the hot zone (see cross-section in Fig. 3) were also made of recrystallized silicon carbide. This is done because this is an extremely good heat conductor. It might reasonably be supposed that the septum plate immediately below the resistor would be at a very much higher temperature than any other part of the inside of the tunnel radiating heat to the ware on the cars. While this part of the septum plate no doubt has a higher temperature than the rest this excess is actually small because of the high heat conductivity of the recrystallized silicon-carbide septum and bricks.

In firing biscuit ware properly in any kind of kiln there are two factors which must be considered, time and temperature, for there is a limit to the rate at which it can be heated, and the temperature to which it must be raised lies between certain limits.

In heating ware in a tunnel kiln these same two factors, time and temperature, must be considered. Assuming that the kiln walls are maintained at a fixed temperature the rate at which the ware is heated will depend upon the rate at which it travels through the kiln and consequently its temperature at any point in the tunnel will depend upon the uniform rate at which the cars are moving and upon the temperature gradient in the kiln.

Data on Design The data for the design of the experimental kiln were as follows:

Dimensions of car top	18 x 34 inches
Maximum height of ware	6 "
Car top to septum	8 "
Car load:	
3 bungs 7 inch plates	52.5 pounds
3 bungs 4½ inch plates	28.5 "
1 bung 5½ inch plates	8.5 "
Miscellaneous	9.0 "
Total weight of ware	98.5 "
Output per hour	1 car

To complete the data required for the design of the kiln it would be necessary to have a curve with abscissas as distances from the entrance to the tunnel and ordinates as temperatures of the ware. As the data

for this were not available it was necessary in preparing the design to assume a curve of this kind.

The metallic resistors for the preheating chamber and the graphite resistors for the hot zone were designed to give the required power distribution in the tunnel. Since this was based on an assumed car position-temperature curve it was quite certain not to be correct, therefore some method of adjusting it was required. Accordingly the terminals of the grids making up the hot zone resistor were used for connecting external shunts for varying the power in each grid. This is satisfactory for experimental work; but for commercial practice the more economical method of varying the power by changing the voltage at the terminals of the grids would be employed.

This paper being intended merely as a description of the construction of the electric kiln, a description of its operation will be given at a later date.

My thanks are due to the Buffalo Pottery Company for permission to publish the photographs and some of the data in this paper.

THE FITZGERALD LABORATORIES
NIAGARA FALLS, N. Y.

SOME FUNDAMENTALS OF TERRA COTTA[1]

By Harry Spurrier

ABSTRACT

Terra cotta is not a definite material. Considerable difference of opinion exists as to suitable structure and composition. There are more differences between different makes of terra cotta than there are in opinion as to what it should be. Microscope study of thin sections of terra cotta is a valuable method of examination. The voids in terra cotta are of more than one kind and origin. The grog used in terra cotta is frequently unsuitable as to character and size. A fuller knowledge of fundamentals will probably much alter ideas as to suitable grog. A test for internal stress is described. Terra cotta was tested for osmotic action. The internal degradation of terra cotta is demonstrated by two different methods. A number of slides are presented being typical of certain characteristics.

During the past two or three years the writer has been called upon to make tests on terra cotta, having in view some specific objective. It therefore became necessary to investigate the literature and become acquainted with the customary tests and the deductions drawn from the results of these tests. Furthermore a personal need was felt for an intimate knowledge of the structure of terra cotta, both macroscopic and microscopic. As these preliminary investigations progressed it was borne home very strongly that terra cotta was not a definite material, either as to composition or structure. An investigation of these differences was made, to develop if possible, a connection between the mental concepts of terra cotta makers in regard to an ideal terra cotta. This effort tended to add to the confusion in regard to what terra cotta should be.

Experiments were then made purely for personal guidance in regard to physical characteristics of the varieties as found upon the market. Again there was recorded an enormous divergence between different varieties and also between different specimens of the same manufacture.

This difference between different samples of the same manufacture can and does arise from a number of contributory factors, which may be classed in the following general way: (1) differences of which the maker is ignorant; (2) differences of which the maker is cognizant, but to which he is indifferent; (3) differences arising from variations in raw material (*a*) unavoidable, (*b*) avoidable, but tolerated; (4) differences arising from lack of proper control of materials and machinery; (5) differences arising from variations in the chemical and physical character of the ingredients brought about by conditions of supply, etc.

Aside from all this there remains the fact that there is no agreement as to what constitutes the best terra cotta.

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[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (Terra Cotta Division.)

It would, I believe, be impossible to get two manufacturers of terra cotta to write out independent specifications for the material, which would show particular agreement. This probably arises from the fact that there are a number of variables to contend with in each individual case, as much as from difference of individual ideas.

There are, however, a number of points about which a well-defined general agreement could be established, which at present lack any great degree of definition.

Microscope Survey

A microscopic study of a considerable number of bodies brought out several points of fundamental importance, attention to which might improve the body.

Voids There was at once noted a very wide difference in the amount of voids in any given area, varying all the way from well over 40% down to how little I do not know, but never very little. The voids here considered are not those of large air inclusions consequent upon the body not being rammed home, but those easily distinguished as being consequent upon the mixing operations.

At first these voids could not be related to any particular direction or orientation and they seemed to lack any character that would aid in diagnosing a cause for their distribution. As experience accumulated it was observed that their occurrence was commonly associated with coarse grog particles and it was discovered that the movement of such coarse particles in working the body caused a separation of the body and consequently a trailing void. It should not be difficult to remedy this state of affairs, especially in aggravated cases.

Grog The heterogeneity of the grog in many cases is cause for a great number of defects, which, taken collectively, are serious enough to call for careful attention.

The practice of using grog without regard to its physical character is not to be recommended as it is the cause of considerable disturbance. The question of coefficiency of volume under temperature changes has received all too little attention. In numerous cases the grog particles had fluxed to the body, only to be ruptured as the body of higher cooling shrinkage pulled them apart; and, at times, exactly the reverse of this phenomenon had taken place.

Such a condition presents an admirable nucleus for cooling cracks to start and when once started no one can foresee the end. This merits serious consideration with excellent prospects of an abundant return.

If grog is made from the same clay as the body and fired to the same time and temperature schedule, it would be possible to revise much of the accepted data as to the function of grog and also the desirable

limits as to size and quantity. It is confidently believed that grog data has been amassed with so many variables as to make some of the conclusions of questionable value.

Study of Sections It is quite certain that coarse grogs make for excessive porosity, which will later be shown to be undesirable. Much valuable information accrued during the cutting and grinding and mounting of the specimens used in this work, and although such evidences as those referred to later require some experience and a little skill for their proper interpretation, the results are well worth the work involved.

The pieces of terra cotta used were never hammered or broken, but the portion used for the slide was invariably sawed out of the solid piece, with a revolving disk of thin sheet metal, provided with a large number of fine indents made by gently striking the disk with a knife blade. The disk was armed with a mixture of 120-mesh Carborundum and oil.

A little experience with the sound made during this cutting soon enables one to tell accurately the nature of the body being sawed, but it is impossible to describe this in words.

It will also be noted that soft, friable, highly porous, and hard bodies, all give their characteristic note and sensation to the hand during sawing. The soft and porous bodies take longer to cut than the dense and hard bodies and are far more difficult to handle. For instance, glass cuts more easily and faster than terra cotta.

Having cut the desired section, it is ground down to a plane and very smooth surface on one side. The specimen is now washed free from oil and Carborundum and dried thoroughly; it is then cemented to a section of plate glass which has been ground on one side and very carefully measured with a micrometer.

The further grinding of the specimen is continued with the necessary precautions until the mount measures one or two thousandths of an inch greater than the plate glass.

The fine grinding being finished, the thin section is removed from the glass plate by the aid of hot turpentine and a section lifter, using the precautions always necessary in preparing petrographic sections.

The delicate section is now washed in ether and dried.

We now arrive at the important point that has rendered the foregoing description necessary.

We have secured a plane slice of terra cotta somewhere between one and two thousandths of an inch in thickness, and with such a degree of attenuation the specimen is quite flexible. Should there have been any internal strain in the body it will now cause the thin section to curl up a little, and this is really a very delicate means of demonstrating

the presence of internal strain in a body. Even if no microscope study is to be undertaken this simple procedure is well worth while to anyone desirous of knowing somewhat of the strains in terra cotta.

There is quite a difference of opinion as to whether a close or open body is the more desirable, and while allowing perfect freedom to all to settle this moot question in their own way, the results of some carefully made experiments might present some new angles to both the tight and loose arguments.

The flexibility of even a moderately thin piece of terra cotta about .005 inch thick is very small indeed and if porosity aids flexibility, such aid is amply supplied by a degree of porosity far less than that exhibited by the densest piece of terra cotta I have ever seen. I hope in the near future to have precise figures on this.

Osmosis as Cause of Terra Cotta Breakdown

It had occurred to me that possibly osmosis might be a factor in the breakdown of terra cotta. The speculation looked fairly plausible, when considered in the light of the fact that terra cotta shows a solubility as high as .75 of 1%. Suppose we have a free standing piece of terra cotta well saturated with water, or even only locally saturated; the water of saturation becomes a weak solution of the soluble portion of the body. If the sun should shine upon a rounded surface, or for any cause some of the solution should be evaporated locally, say on a curved exterior, the solution would become locally more concentrated and then according to the laws of osmosis a flow will develop directed toward the area of concentrated solution and from the inner areas of less concentrated solution, thus setting up osmotic pressure. Should this flow develop a rate greater than that of the natural passage of the liquid through the body, it is clearly conceivable that rupture might ensue because osmosis can and does develop very high pressures indeed.

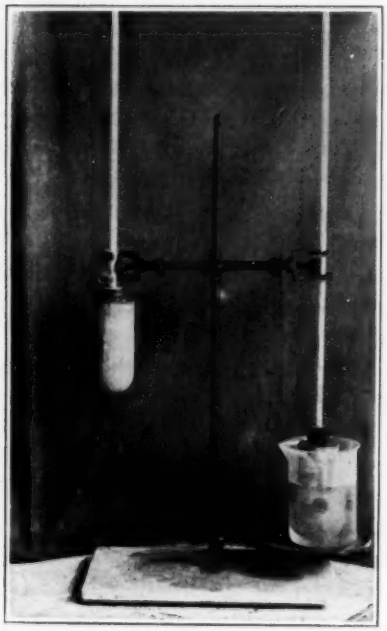

FIG. 1.

Accordingly I had some tubes of terra cotta made similar to a very large and thick test tube. The opening was ground to a true circle and the upper one inch was well soaked with melted paraffin wax; a good rubber stopper fitted with a straight and vertical glass tube completed the special part of the apparatus.

The terra cotta tube and part of the glass tube were filled with a molar solution of salt and the terra cotta tube was immersed in a beaker of distilled water. (See Fig. 1.)

Internal Structure Fractured by Freezing and Thawing

Under these conditions had there been any osmotic action, the distilled water would have forced its way into the tube and developed a pressure which would have been indicated by a rise of the salt solution in the glass tube. However, no such result occurred and it became evident that osmosis may be disregarded as a factor in the breakdown of terra cotta insofar as large areas are considered. Further reflection led me to believe that there might be and probably was a considerable change in the internal structure of bodies, occasioned by repeated freezing and thawing of wet terra cotta, long before the spalling of the exterior of the body takes place.

Accordingly a set-up was used similar to that described for the osmosis test, but with this difference: the tube was filled nearly to the top of the glass with distilled water and the rate of the descent of the water level in the glass tube was taken as a measure of the passage of water through the body, say so many millimeters in 20 seconds; having established this rate with a stop-watch, the terra cotta tube was placed in a water tight can and immersed in distilled water and the whole frozen solid and chilled to a temperature of $-10°C$.

After thawing, the experiment previously described was repeated with the interesting result that the rate of water flow through the body had increased more than threefold, by simply freezing the body once.

On each successive freezing and thawing an increased water flow rate was recorded.

This can be interpreted in only one way, namely, the passage ways by which the water passed through the body had been increased by internal disintegration of the body.

It was sought to confirm this interesting finding by attacking the problem from a rather different angle. If the terra cotta suffers internal disintegration in freezing, it was extremely likely that some, at least, of the closed pores would be broken open and that, were it possible to make per cent porosity tests with sufficient accuracy and constancy, this would be a crucial test.

During many porosity determinations a method and technique have been developed which have proved very accurate indeed and although a

porosity difference of very small magnitude was anticipated, it was confidently believed that it might be very positively measured.

Accordingly, two 10-cm. cubes were prepared and the porosity determined with the utmost care, even to the weighing of the bodies in a completely dried state, which made a difference of .5 gram on a weight of over 800 grams and atmospheric humidity of 32.5% at a dry bulb temperature of 64°F. In each case the porosity was found to be about 1.25% greater after freezing than before.

It may therefore be stated that the terra cotta body suffers internal breakdown at the very first freeze while in a saturated condition, that this degradation is cumulative, and the spalling on the exterior is probably only the full stop at the end of a long chapter, in the earlier stages of which a great deal takes place that to date has escaped our attention.

Another factor not commonly recognized might be well worth mentioning in closing. Suppose that a free standing piece of terra cotta becomes thoroughly wetted internally and is then frozen at a temperature of about 28°F. A surface of frozen material is produced and as the frost goes deeper the enclosed water expands in the process of freezing; exudation is arrested by the ice coat already formed and considerable pressure must be developed internally. If now the temperature drops rapidly to about zero, the internal ice will suffer a considerable contraction and drag vigorously on the small particles to which it is attached. We now have a very destructive agent at work and, withal, a very subtle one. This contribution is offered in the hope of stimulating research in this and other directions with the aim that some day we may be able to state precisely what terra cotta should be, both compositionally and structurally.

NORTHWESTERN TERRA COTTA CO.
CHICAGO, ILLINOIS

PERSONAL EXPERIENCES AND NATIONAL LIFE AS SUBJECT MATTER FOR DESIGN[1]

By Myrtle Merritt French

ABSTRACT

Artists who lack ideas for design often resort to copying something made by a different people to express the life of a different age. As a result the design does not express America and is not in harmony with the natural expression of the American home. Many interesting symbolic designs have been worked out in class using personal experiences for the subject matter. Thus the designs have a new interest both to the artist and the public. If American industrial art would encourage the artistic use of the wealth of material in our national life, the products produced would be given a soul which would make them alive.

For some time much energy has been spent on scientific and technical subject research; it is high time that a few now turn the attention to art research to discover how the artistic quality of ceramic wares may become a living expression of vitality and to find out how that force can best fit into a bigger and finer educational and commercial scheme.

The idea of using personal experiences and national life as subject matter for ceramic design grew from the feeling of a need of something vital to express in order to give individuality and strength to patterns. It was observed that when the students did pageantry for their big annual ball, there was no lack of real beauty through their patterns and, yet, when it came to decorating a piece of pottery, too often they were baffled or resorted to the same old ideas of a peacock, windmill, Japanese lantern, or boat. Far too few developed an original expression on any subject.

When a student was asked why the class did such fine decorative things in pageantry but had so few ideas in pattern for a pot, the reply was, "Oh! the pageant is our own expression for our own lives. It means something to us, we are free to do as we choose."

Fig. 1.—Sketch from an incised tile made by a student of the Art Institute of Chicago. It symbolizes an auto trip. Explanation: In the center is a tourist camp with a fire around which are eight tourist tents. Outside that is the road (in white) with gas stations at intervals. Farther out are symbols of mountains and foothills, some of which are wooded. Between them is the sun. In each corner of the square center is a spot representing "the places we didn't get to see." The border symbolizes watermelon and other fruit eaten along the way.

[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (Art Division.) Received September 23, 1926.

That remark was worth considering. The result was the following experiment.

A tile problem was given, the design of which was to represent some personal experience treated symbolically. The tile was to have a beautiful pattern for both observer and creator, but to the latter it must have a significance which might or might not be apparent to the former. The pattern *must not* be a picture, but a symbol. Already the students had known of the Indian symbolism and were urged to catch that spirit in expressing their own lives by their *own* symbols. The architectural plan of each pattern was first chosen and then the fun began. A few knew exactly what they wanted to say, but most of them floundered for a time. By the end of the first lesson nearly every member had made a good start. When the tiles were completed they were the best set ever produced in any class by a similar group, and many said they had enjoyed making them more than any other design.

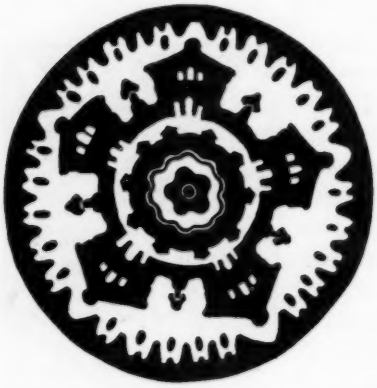

FIG. 2.—Sketch from a plate made by a student using colored glazes. An incised line separated the colors. It symbolizes the most important experiences in the life of the student. Explanation: The central flower-like form symbolizes the family of five as a center. Grouped next to it are the schools attended before going to the Art Institute of Chicago. The largest dark spots suggesting the shape of a building represent the Art Institute. Between them is a mountain in Colorado on top of which is a cabin. The larger points at the border represent the mountains, the smaller ones, foot-hills. The isolated black spots symbolize a special hill.

The following year a plate design in the same spirit was added to the tile problem, but the subject matter as suggested was to be a national institution instead of a personal experience. Quite a list was given, some of broad scope and some of narrower, with a chance to choose a different subject if desired. The following is an outline.

1. Transportation Symbolized by a movement in a particular direction: (*a*) aeroplane, (*b*) steamer, (*c*) electric, (*d*) horse, (*e*) auto, (*f*) rail, and (*g*) bicycle.

2. Industries Symbolized by a feeling of growth, probably upward: (*a*) mining, (*b*) agriculture, (*c*) manufacturing, (*d*) construction, and (*e*) municipal activities.

3. Business Symbolized by repetition: (*a*) merchant, (*b*) baker, (*c*) laundryman, and (*d*) restaurant.

4. Industrial Arts Symbolized by more delicacy: (*a*) printing, (*b*) weaving, (*c*) blacksmithing, (*d*) cabinet making, and (*e*) pottery.

5. Day Labor Symbolized by strength of the individual: (*a*) street cleaning, (*b*) street repairing, (*c*) ditch digging, and (*d*) teaming.

In working out this problem most of the students took material of much narrower scope than outlined, such as apple industry or the growth of plants in a conservatory. Only the more intellectual ones tackled the broader subjects. One attractive plate design represented immigration, the home land in the center, the voyage across the ocean to the new country at the border.

FIG. 3.—Sketch from a plate made by a student using blue slip on cream colored clay, and glazed with a colorless transparent glaze. It symbolizes a visit to Hull House Settlement in one of the foreign centers of Chicago. Explanation: In the middle is represented a crowded center. Around it are four street booths in which fat women are waving their arms to attract sales. Between the booths are fruit baskets, over the baskets the Jewish star, and on each side of the star are old ash cans. Over the roof of the booth is the sign of the three balls. Around the central medallion is a border of cheeses hanging in the shop windows along the street. The heaviest dark border toward the edge, represents Mrs. French's little bungalow home built on the roof of the Boy's Club at Hull House as main spots. From it can be seen the city as a mass, above which are chimneys and water tanks. The outside border symbolizes the sun half-hidden by the atmosphere and clouds of smoke hanging over the city.

Students in pottery never having had design have been given the idea of the personal experience with good results. Without art training a beginner is usually scared because he has nothing to say, but when he can tell his own story by means of symbols instead of pictures, often he is freed. Many people have a feeling for the architectural plan of a design, and usually that is all the beginner of design has. With the added possibilities of symbolizing something from personal experience, a good decoration often follows, otherwise a design suited to embroidery, advertizing, woodcarving, or metal would be copied and the result would be unsatisfactory.

In using this idea for teaching, the first difficulty the instructor has to face is the impulse of the student to picture the experience, because he knows pencil and paper but does not know clay. He will soon discover clay and get a feeling for his material, if the instructor insists upon a

bold, direct handling of the clay. The second difficulty is, that the student gets so interested in the picture (or symbol, when he has caught the spirit) that he forgets the pattern. By making him criticize his own tile for pattern and work with it bottom side up or corner-wise, he gets an original, live pattern of his own invention. This is, generally as good as, and usually better than, what he could produce by a rehashing of the expressions of an unknown people with different ideals, no matter how beautiful that expression has been. He has said something and he has said it in his own way, a great triumph over a mechanical copy or a weak reiteration of what some one else said beautifully.

If the subject matter of the natural expression of a child is observed it will be noticed that it is his own experience in some form, his every day life, his imagination or stories or pictures, which have held his interest. Through a study of the best primitive art it is found that the patterns invariably symbolize something vital. The art of the Mexican schools, which developed such fine expression, was founded upon seven symbols of their lives. Some of the finest old Persian rugs are symbols of the plan and activities of the little village where the rug was made. And so we could continue indefinitely. American industrial art, as a whole, has become mechanical and devitalized. It is up to us as educators and producers to give our art expression, a soul which will make it live.

Art Institute of Chicago
Chicago, Illinois

CERAMIC ABSTRACTS

Compiled by the

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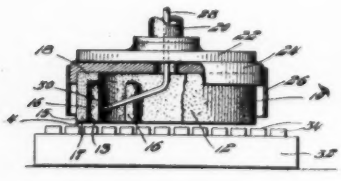
Abrasives

Abrasive products finish leather. HERBERT R. SIMONDS. *Abrasive Ind.*, **7** [9], 276 (1926).—The finishing of leather skins by the use of abrasives in the manuf. of suede leathers is described. C. J. H.

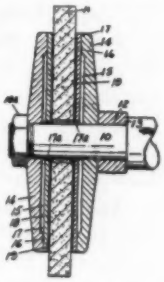
Grinding and polishing room exhaust practice. H. W. PFEFFER. *Abrasive Ind.*, **7**, 287 (1926).—Data is given for the proper installation of exhaust fans and equipment. Proper design of protection hoods is shown. Tables are given showing the friction losses of air in pipes. C. J. H.

PATENTS



Grinding wheel. D. D. MACLAUGHLIN AND W. B. LEONARD. U. S. 1,600,054, Sept. 14, 1926. A grinder for use in surface grinding comprising a cylindrical integral ring of substantial depth having a wall of inherently abrasive material, having an annular grinding face on one end thereof having grooves extending substantially radially part way across

from the inside edge thereof and upwards from annular grinding face on the inside edge of the wall of ring, the bottom of grooves being parallel to the axis of the grinder, grooves being adapted to receive a coolant therein to cool and lubricate the grinding surface of ring against the work, coolant being thus urged against the bottom of grooves in a direction normal thereto by centrifugal force and prevented from escaping from the open ends thereof by the surface of the work being ground and prevented from splashing radially outwards by the portions of ring exterior of grooves, and the opposite end of ring shaped to be mounted on a grinding machine chuck.



Mounting for abrasive wheels. G. W. PERKS. U. S. 1,600,064, Sept. 14, 1926. A mounting for abrasive wheels including a rotary shaft and means for clamping the wheel to shaft, including a pair of clamping elements each having relatively stiff gripping members with a film of yielding, tough rubber vulcanized thereon, the thickness of the film being comparable to the depth of the interstices of the surface of the wheel.

Ceramic safety tile. M. C. BOOZE. U. S. 1,600,925, Sept. 21, 1926. A safety tile comprising durable, wear-resistant, anti-slipping grains of porcelain, bonded into an integral, non-homogeneous, highly porous mass by a vitrified ceramic bond of a nature softer than the grains. A safety tile comprising anti-slipping abrasive grains of hard and tough porcelain and a bond of vitrified ceramic mat. united into an integral highly porous mass, said bond forming between 25 and 60% by weight of the total mass and being more vitreous at the temp. of firing than the grains.

Art

Art and the manufacturer. F. J. M. KOENIG. *Bull. Amer. Ceram. Soc.*, **5** [9],363–65 (1926).—The development of unity among decorative artists and their coöperation with industry in foreign countries is discussed. The need of measures similar to those used in foreign countries for improvement of quality production to stand foreign competition is stressed. E. J. V.

Ceramic products in landscape architecture. P. H. ELWOOD. *Bull. Amer. Ceram. Soc.*, **5** [9], 366–68 (1926).—Changing conditions which are making this a propitious time for ceramics as in industry associated with buildings and gardens are discussed. For tasteful and appropriate use of ceramic products by a landscape architect there must must be a greater visible use of tile and terra cotta in building construction by the architect. Harmony of the architectural treatment of a house with such features as a tile-roofed shelter, tile seats, tile pavements, etc., is essential. Proper selection and use of pottery in a garden is an art as is shown by E. in his discussion of its use and abuse. E. J. V.

The inside frosting of incandescent lamps. MARVIN PIPKIN. *Ind. Eng. Chem.*, **18** [8], 774–76 (1926). See also partial reprint in *Nat. Glass Budget*, **42** [17], 16 (1926).—Diffused light was best produced by etching or frosting clear glass globes of electric lamps. Past practice of frosting the outer surface produced an easily soiled article which was hard to clean. To overcome this objection, attempts were made to frost the inside surface of bulbs, but this left them very weak and fragile. Time, temp., concentration, chemical composition of frosting medium and of the glass control the quality and structure of the frosted glass surface. Results of a number of tests with an ivory ball tester to determine comparative strength are given. Various frosting mixtures used are discussed. Most economical frosting mixture is one that produces good frosting quickly. While inside frosting reduces the strength considerably, treatment with a suitable solution relieves the weakness. Results of various detailed tests are enumerated. Also in *Glass Ind.*, **7** [9], 217 (1926). E. J. V.

Hires Turner Glass Co. announces intaglio line of decorative mirrors. ANON. *Amer. Glass Rev.*, **45** [47], 30 (1926).—Announcement of a new line of art mirrors is made and a brief description of some of the outstanding features given. E. J. V.

Preparing steel plates for deep etching. R. SEDLAK. *Pottery Gaz. and Glass Trade Rev.*, **51** [591], 1407–1408 (1926). Reprinted from *Amer. Glass Rev.*, **45** [36], 19 (1926). See also *Ceram. Abs.*, **5** [8], 239–40 (1926). E. J. V.

Chinese blue and white porcelain. JOSEPH BURTON. *Pottery Gaz. and Glass Trade Rev. Supp.*, **51** [591], 1–3 (1926).—An illustrated, descriptive article on the decoration of Chinese blue and white porcelain. E. J. V.

Automatic decal machine helps potters. ANON. *Ceram. Ind.*, **7** [2], 126 (1926).—The ware is delivered from the white warehouse to the machine in the usual way. It is then sized by hand and placed on a revolving wheel, which carries it through a tunnel or zone of high velocity air. The ware dries perfectly in about 55 sec. As the ware emerges from the tunnel, the transfer is placed on it and the piece is again placed on the belt which carries it to the operators who rub the print down. The ware is then placed in ascending V-shaped baskets, and these baskets are timed to travel a certain distance which permits the pigments to fully adhere to the sizing on the ware. This is found to be a very important feature, as the decal transfer to the sizing is a progressive operation and does not take place immediately as popularly conceived. The ware then advances under a water bath so as to remove the paper. An advantage of this machine is that skilled operators are not necessary as the operators can be trained to maximum production in 4 days. F. P. H.

Undesirable colors in ceramic bodies. J. BIET. *Tonind. Ztg.*, **50**, 935–36 (1926).—The reduction of FeS_2 in porcelain results in spotted ware which must be sold as seconds. This can best be remedied by substituting a new clay for the one containing FeS_2. Finely divided Fe_2O_3 gives the porcelain a cream color which is undesirable. If this Fe_2O_3 is reduced to FeO it is not nearly so detrimental. Bodies containing Fe_2O_3 should be reduced at a period when the body is still open and porous. This is between 900 and 1050°C for porcelain bodies. Another impurity which colors porcelain is C. If this is not thoroughly fired out of the body when it is still porous it will give the same a bluish tinge. C, which is deposited on glazes, is also harmful. When certain fuels like wood are thrown on a fire, the unfired hydrocarbons often reach the ware and separate into C and H in the blaze. This has a tendency to darken the glaze. H. G. S.

The coloring effects of different oxides and minerals upon stoneware bodies. E. BUSZ. *Keram. Rund.*, **34**, 533–36 (1926).—B. studied the effects of CuO upon the color of stoneware. Different colors were obtained from CuO depending upon the clay used. H. G. S.

Notes on antimony yellows.—I. A. CHAMBERS AND J. F. RIGG.—*Trans. Ceram. Soc.* (Eng.), **25** [2], 101–107 (1926).—Naples yellow is the same substance as that known in Naples under the name of Giallolini. The process by which it was first made was long kept secret. The oldest known directions for the preparation of the color are those given in 1758 by Passeri. The present work was carried out with the object of developing suitable antimony yellows for ceramic purposes. Use has been made of the familiar triangular diagram to represent the results obtained with the 3-component system PbO-SnO_2-Sb_2O_3. The materials used were red lead (Pb_3O_4), tin oxide (SnO_2), and antimony oxide (Sb_2O_3), and these were used in all excepting the preliminary experiments. Litharge (PbO) was used in these initial trials but was abandoned in favor of the lead oxide with the higher oxygen content. The oxides were thoroughly mixed in the proportions shown in Table I. No. 6 (60% red lead, 40% antimony oxide) was the only one found to give a good yellow color. The remainder were mainly pale in hue. The

addition of tin oxide to the colors was made and good colors were obtained from 3 mixtures. None of the remainder appeared to be of much value. Where iron was added as the oxide the color was apparently improved, becoming browner as the per cent of iron increased. The addition of similar quantities of iron oxide in the shape of iron frit did not seem to make so marked a difference.

No.	Red Lead Pb_3O_4	Tin Oxide SnO_2	Antimony Oxide Sb_2O_3	No.	Red Lead Pb_3O_4	Tin Oxide SnO_2	Antimony Oxide Sb_2O_3
1	100	—	—	12	20	60	20
2	80	20	—	13	20	40	40
3	80	—	20	14	20	20	60
4	60	40	—	15	20	—	80
5	60	20	20	16	—	100	—
6	60	—	40	17	—	80	20
7	40	60	—	18	—	60	40
8	40	40	20	19	—	40	60
9	40	20	40	20	—	20	80
10	40	—	60	21	—	—	100
11	20	80	—				

R. F. S.

Art in industry: what is the value of design? RICHARD F. BACH. *Ceramist*, **8** [4], 213–26, (1926).—B. uses simple illustrations to show the importance of design and the difficulty of estimating its cost. The whole product means material plus labor multiplied by design. A handful of notes thrown at a staff is a discord; the same notes arranged according to an intention of mind is a harmony. The difference is design. Skill of manipulation by itself results in duplication or in merely aimless virtuosity unless controlled by art, in which case it becomes design. The salaries of the designers do not indicate the cost of design in the product. Design is the making and breaking of an object of art. Drawing in design is only a means to an end. Design is an ineffable quality, like good will in business. B. points out how the Metropolitan Musem can coöperate with the ceramic industry. Several reproductions of priceless pottery specimens, tiles, etc. illustrate the paper. A. E. R. W.

Black and gray in visual theory. G. J. RICH. *Amer. Jour. Psych.*, **37**, 123–28 (1926).—Discusses the question, "What constant best explains the facts of vision, black or gray?" R. leans to gray. H. H. S.

The Ostwald color-system. C. SCHAEFFER. *Physikal Ztg.*, **27**, 347–53 (1926); *Chem. and Ind.*, **45B**, 639 (1926).—Ostwald's absolute system is criticized by showing experimentally that insertion of dark sectors in a color circle reduces brightness in a manner which is exactly counterbalanced by increased intensity of illumination. This result is opposed to O's. theory. Further theoretical and experimental arguments are adduced against the theory that color can be expressed quantitatively by the 3 terms, pure color, white, and black. H. H. S.

Cement, Lime, and Plaster

A new lime burning method. ANON. *Chem. Age*, **15**, 174 (1926).—A sintering machine using traveling pallets with perforated floors permits use of small stones, which cannot be utilized with rotary kiln. Reference is to publication Serial 2762, of Bureau of Mines, Dept. of Commerce, Washington, D. C. E. E. P.

The coloring of cement, concrete, and other building materials. L. F. GOODWIN. *Can. Chem. Met.*, **10** [9], 211–12 (1926).—G. N. White has developed a new process for coloring cement and concrete, utilizing a large number of organic dyes which are particularly fast to light, moisture, and atmospheric effects, and which are completely insoluble in water. Instead of gaging the concrete with water and adding the color in powder

form, it is gaged with a solution of some simple derivative of the coloring matter which, on exposure to the air or by other simple treatment, is thrown down in a permanent insoluble form upon the concrete particles. The depth of tint is dependent only on the ratio of dyestuff to cement; so long as this is constant, it is immaterial as far as the color is concerned to what extent sand or other aggregate is added. See also *Ceram. Abs.*, **5** [8], 240 (1926). E. J. V.

The Portland cement industry. RICHARD K. MEADE. *Ind. Eng. Chem.*, **18** [9], 910–13 (1926).—The development of the American Portland cement is traced from its inception in 1875 to the present date. The methods in use then and now are compared and discussed. The theory of cement manufacture and results of investigations which clarified many points pertaining thereto are listed. E. J. V.

Effect of time and temperature of firing on the properties of lime. R. T. HASLAM AND E. C. HERMANN. *Ind. Eng. Chem.*, **18** [9], 960–63 (1926).—Two limestones, one an Eastern stone not usually considered capable of producing a plastic hydrate, and the other an Ohio stone that does give a plastic hydrate, were used in this investigation. The procedure followed is outlined. Results obtained show an optimum temp. on time of firing for the production of the most plastic lime and these conditions produce a very plastic hydrate from each limestone. The rate of interaction of the lime hydrates with acid, the rate of settling, and the volume of putty all vary with the plasticity. The indication is that fineness of the hydrate particles is an important factor in producing a plastic hydrate. E. J. V.

Calcium sulphate as a retarder for Portland cements. K. GOSLICH. *Tonind. Ztg.*, **50**, 995–96 (1926).—Fired gypsum is a better retarder for cements than raw gypsum. Anhydrate has practically no retarding effect. H. G. S.

The production of anhydrate cements. P. P. BUDNIKOFF. *Tonind. Ztg.*, **50**, 1009–11 (1926).—B. studied the effects of CaO, NaOH, $Cr_2.3SO_4K_2SO_4 + 24H_2O$, $(NH_4)_2SO_4$, Na_2SO_4, $FeSO_4$, and H_2SO_4 upon the strength of dead burned gypsum cements. It was found that some of the chemicals improved the cement when added in certain amounts and in other cases they decreased the strength of the cement. H. G. S.

Corrosion of concrete. J. R. BAYLIS. *Proc. Amer. Soc. Civ. Eng.*, **52**, 549–79 (1926); *Chem. and Ind.*, **45B**, 441 (1926).—Corrosion depends on solubility of $CaCO_3$, and this is determined by alkalinity, p_H, and salt content of surrounding water. The parts $CaCO_3$ dissolved per million is a good guide to the state of the concrete; a value below 200 indicates that disintegration is likely to occur rapidly. The actual rate of disintegration is dependent on the porosity of the mortar binding the larger aggregate. H. H. S.

Determination of soluble silica in cements, mortars, and concretes. D. FLORENTIN. *Compt. rend.*, **183**, 53–55 (1926); *Chem. and Ind.*, **45B**, 668 (1926).—One g. of cement, or 4 g. of mortar, is added little by little to 50–60cc HCl *d* 1.12. The solution is filtered and the SiO_2 in the filtrate rendered insoluble, and estimated in the usual way. H. H. S.

Cements. H. KEEBLE. *Queensland Govt. Min. Jour.*, **27**, 255 (1926).—Difference between "quick hardening" and "quick setting" is shown. By rapid hardening is meant maturing; such cements are slow setting, giving ample time for the worker to mix concrete and place it, but once the cement or concrete has lost its plasticity, or become set, then maturing takes place very rapidly. Quick setting cement loses its plasticity quickly (about $\frac{3}{4}$ min.). Although the concrete will appear to be hard in a short time, it may be weaker at the end of 24 hrs. than ordinary slow-setting Portland cement the same age; in fact, quick setting is detrimental to the ultimate strength of cement and rarely attains to the same ultimate strength as slow-setting Portland cement. Quick-setting cement has its uses, where water has to be dealt with for sea work, especially

where concrete has to be placed between tides. The principal elements of Portland cement are lime and silica; the elements of the aluminous cement are mineral bauxite and limestone. Rapid hardening cements can be divided into 2 classes, Portland and aluminous; the trade name of the former is "Ferrocrete," and of the latter is "Lightning" cement. K. discusses the various merits of each cement; aluminous cement has advantages for certain concrete work which must be made use of in 24 to 48 hrs. In setting, aluminous cement generates heat internally; it is essential that the surface should be kept wet after the concrete is set to prevent its powdering. This generation of internal heat renders it almost immune from the action of frost. If aluminous and Portland cement are mixed together the result is a quick-setting cement; it is essential that all tools, mixers, etc. be thoroughly cleaned before using the 2 cements. (Read before the Master Builder's Assn.) O. P. R. O.

Enamels

Practical chemical control of pickling room solutions. B. T. SWEELY. *Jour. Amer. Ceram. Soc.*, **9** [9], 590–92 (1926).—This paper gives a brief outline of pickle room practice and gives in detail a rapid method of titration of solutions by use of especially graduated cylinders and the addition of indicator to normal or fractionally normal solutions.

The theory of cleaning of sheet iron and steel for enameling purposes. HOMER F. STALEY. *Jour. Amer. Ceram. Soc.*, **9** [9], 593–97 (1926).—Cleaning may be done by sand blasting, heating, use of solvents, or use of alkaline solutions. Of these methods, heating and use of alkaline solutions are important at present. In cleaning by heating the best results are obtained when the articles are first dipped in a solution of acid heated uniformly to the lowest temperature that will cause the oils and greases to be burned off, and cooled slowly, both heating and cooling being done with the admission of as little air as possible. In cleaning by the use of alkaline solutions, saponifiable oils are removed by the formation of soaps and the subsequent solution of these; non-saponifiable oils are removed by emulsification. Efficient cleaning depends primarily on the choice of cutting and drawing oils so as to have present a proper ratio of saponifiable and non-saponifiable oils. The cleaning solution must vary in composition according to the kinds and amounts of oils to be removed.

The influence of different electrolytes upon enamels. A. OTREMBA. *Keram. Rund.*, **34,** 506–07 (1926).—When enamel slips are taken from a mill they are usually too fluid and must be thickened by adding suitable electrolytes. O. tested the effects of $MgSO_4$, NH_4Cl, Na_2CO_3, $Na_2B_4O_7 + 10H_2O$, Na_2SO_4, and NaCl upon the viscosity of 2 enamel slips. O. found that $MgSO_4$ increased the viscosity the most but cautions the reader against using it since SO_4 may cause a dulling of the enamel. NH_4Cl is almost as effective as $MgSO_4$ since it is practically all volatilized and does not affect the enamel. Too much $Na_2B_4O_7 + 10H_2O$ is required to thicken the enamel, about 5 % being necessary. Large amounts of Na_2CO_3, Na_2SO_4, and NaCl are also required to thicken enamel slips and their use is not promising. Chlorides have a dull effect on enamels similar to sulphates. Never use a mixture of NH_4Cl and $MgSO_4$ since this mixture is especially detrimental. H. G. S.

The cooling and disintegration of blast furnace slag and enamel frit. W. ATHENSTAEDT. *Keram. Rund.*, **34,** 538–39 (1926).—Enamel frit may be cooled similar to blast furnace slag. Granulated steam cooled blast furnace slag is in such a condition that it can be easily ground and enamel frits can be similarly cooled to advantage. H. G. S.

Principles underlying properties of enamel suspensions. ANON. *Ceram. Ind.*, **6** [6], 582 (1926).—A preliminary report on the work done at the Bureau of Standards. A number of tests have been made to determine the effect of added electrolyte on the 2 solid phases of an enamel slip. Two factors seemed apparent from these tests: (*a*) that

very small concentrations of electrolytes did affect the clay suspensions, and (*b*) that where the effect was visible it was flocculation in the case of the frit and deflocculation in the case of the clay. Epsom salts was the electrolyte used. F. P. H.

Burner change increases production. ANON. *Ceram. Ind.*, **6** [6], 584–85 (1926).—Description of several pieces of equipment as used at the enameling plant of the Belding-Hall (Mich.) Co. Among these is a pair of huge enameling furnaces using recuperated air. The burner is supplied with fuel oil kept at a constant temperature of 135°F. A large flame burner was needed as the combustion chamber had the unusual length of 9 ft. The present burner throws the flame 8 ft. into the chamber and while it uses 1 to 2 gal. of oil more per hr. than the former burner, it increases the capacity of the furnace 33%. F. P. H.

Relation between enamel and steel studied by the U. S. Bureau of Standards. ANON. *Ceram. Ind.*, **6** [6], 586 (1926).—A study of the effect of varying the feldspar and flint content of enamels on the resistance to mechanical and thermal shock. F. P. H.

Mixing, smelting, grinding of enamels. F. M. BURT. *Ceram. Ind.*, **7** [1] 40–41 (1926).—This is the first of a series of articles on the methods used in enameling practice. The correct method of enamel preparation is discussed. F. P. H.

A laboratory controlled enamel plant. ANON. *Ceram. Ind.*, **7** [2], 141 (1926).—The Chicago Hardware Foundry Company has proven that laboratory control properly conducted is of inestimable value to the plant. The overall scrap loss at this plant is 5%. Description of equipment used at this plant. F. P. H.

Enamel mixing, smelting, and grinding. F. M. BURT. *Ceram. Ind.*, **7** [2] 143 (1926).—Correct methods for raw material handling, smelting, and grinding suggested in this article. F. P. H.

Three days manufacturing time cut to two hours in superenamel plant. CARL W. MEHLING. *Ceram. Ind.*, **7** [3], 229–39 (1926).—A description of equipment used at the enameling plant of the American Radiator Co. Three electric rotary furnaces are used. The ground coat furnace which looks like a large pie with a piece cut out of it, is 75 ft. in circumference. An arc suspended by an angle of about 45° covers the space removed. This is used for loading and unloading of the ware. The firing chamber in the furnace is 24 in. wide, 60 in. high, and the length of travel through the furnace is 54 ft. The first zone of the furnace has a heat of about 1400°F, after which the ware gradually passes into the 1600° zone and then into the zone of about 1200°F. This keeps the ware from warping during the entire firing and also eliminates pin marks. A layout is given which shows graphically the route taken by the ware at this plant. F. P. H.

Pickling iron. H. BABLIK. *Stahl u. Eisen*, **46,** 218–22 (1926); *Chem. and Ind.*, **45B,** 443 (1926).—Pickling effect is greater in H_2SO_4 than in HCl, and less acid is required, but the pickling period is longer. Pickling velocity of HCl rises continuously with increasing concentration for H_2SO_4; maximum velocity is at 25%. At 60°C the pickling velocity of both acids is increased 10-fold. The velocity is decreased by the presence of reaction products; the amount of chlorides to be washed out is less than the amount of sulphates. Boiling water should be used for complete removal. Pickling with HCl is handier and simpler but more expensive. By the use of Vogel's "VBZ" reagent, a saving in iron and acid is effected, and a smoother surface is imparted to the iron. H. H. S.

Chemically resistant steels, with special reference to very high and very low temperatures. T. G. ELLIOT AND G. B. WILLEY. *Chem. and Ind.*, **45,** 526–34 (1926). H. H. S.

Equilibrium relations between iron, oxygen, and carbon. R. SCHENCK. *Stahl u. Eisen*, **46**, 665–82 (1926); *Chem. and Ind.*, **45B**, 633 (1926).—The presence of an iron suboxide stable only below 720°C, and of a percarbide of iron below 600°C, are deduced. H. H. S.

Resistant steels for chemical engineering. W. H. HATFIELD. *Chem. and Ind.*, **45**, 568–73 (1926). H. H. S.

BOOK

Metallurgy of cast iron. J. E. HURST. London: Sir I. Pitman & Sons, Ltd., 1926. Price 15*s* net. H. H. S.

Glass

Tank block corrosion by shelving. F. C. FLINT AND A. R. PAYNE. *Jour. Amer. Ceram. Soc.*, **9** [9] 613–17 (1926).—Photographs are given showing a number of glass tanks which indicate that part of the rapid eating of tank block is due to upward solution from cracks in the block wall. This upward solution is due to the higher specific gravity of the glass after dissolving tank block material. Experiments made by adding clay to glass melted in small pots and analyzing show this. The density is also taken of glass adjacent to the the tank wall.

Temperature of Pyrex and porcelain in the sunlight. J. T. LITTLETON, JR. AND W. W. SHAVER. *Jour. Amer. Ceram. Soc.*, **9**[9], 618–25 (1926).—The relative temperatures of Pyrex glass insulators and porcelain insulators in sunlight are determined in 3 ways. A computation using the radiation and convection heating equations gives a value of 93°C as a maximum surface temperature of porcelain in sunlight, with an assumed shade temperature of 40°C. In a similar way 46.5°C was determined for the Pyrex insulator. Measurements are given of the rise in temperature under natural conditions of Pyrex and porcelain insulators mounted on pins. Temperature measurements were made by means of thermocouples cemented to the surface of the insulators. Extreme conditions were further obtained by means of tin reflectors. Under such conditions the experiments show that the temperature of the porcelain insulator increases on the average about 3½ times that of the Pyrex glass insulator.

The influence of moisture on the mixing of batches for soda-lime-silica glasses. M. PARKIN AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **10** [38], 114–28 (1926).—Soda lime batches containing more than 3% moisture, mixed by hand, were not homogeneous unless sifted after being mixed. Batches of low moisture content (less than 1%) show segregation under vibration; this is not the case with batches containing more moisture. Batches containing 3 to 4% moisture tended to show greater homogeneity on being mixed than those containing a greater or lesser amount of moisture. Light soda ash and very fine limestone tended to give less homogeneous mix than ordinary forms of these materials. Moisture added to batch to improve homogeneity and ease of mixing should be added to the batch as a whole and not to an individual ingredient. The use of wet sand is a common cause of lack of homogeneity in mixed batches. D. J. McS.

The influence of water on the rate of melting and the working characteristics of soda-lime-silica glasses. E. M. FIRTH, F. W. HODKIN, M. PARKIN, AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **10** [38], 129–45 (1926).—Of soda ash-limestone batches containing varying amounts of moisture, those which contained about 1% moisture melted most rapidly, while in the case of similar soda ash-salt cake-limestone batches, most rapid melting was shown by those batches containing about 4% moisture. Soda ash batches containing more than 2% water showed tendency to reboil. Glasses from batches of high moisture content were more viscous and had a shorter working range than glasses of the same composition but made from batches of the usual moisture content. Provided the batches are homogeneous, the presence of varying amounts of

moisture has no effect on the ultimate composition of the glass. Samples of glass from very wet batch showed about 10% greater total loss on ignition than glass from dry batch when heated for 2 hrs. at various temps. up to 920°C under 3–4mm press. All melts made in pots of 25–50 lb. capacity at 1400°C. D. J. McS.

Note on the devitrification of a lead borate glass. C. J. SMITHELLS. *Jour. Soc. Glass Tech.*, **10** [38], 145–47 (1926).—Samples of a very soft basic lead borate glass used for embedding metallographic specimens and over 2½ yrs. old showed marked crystallization on etching, presumably due to slow devitrification at ordinary temps. Newer specimens of the same glass did not show crystallization. D. J. McS.

Some remarks on recuperative gas-fired pot furnaces in practice. P. MARSON. *Jour. Soc. Glass Tech.*, **10** [38], 154–60 (1926).—M. makes numerous recommendations concerning the construction and operation of gas-fired pot furnaces. For furnace sieges M. advises foundation of mixed finely ground potsherds and the smallest amount of plastic clay feasible, rammed *in situ* and covered with 2-in. layer of sillimanite bonded with 8% refractory ball clay. D. J. McS.

A study of some effects of chlorides on the melting and working properties of potash-lead oxide-silica glasses. E. M. FIRTH, F. W. HODKIN, C. M. MUIRHEAD, M. PARKIN, AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **10** [38], 176–98 (1926).—English crystal glass dissolves a maximum of about .70% chlorine, present partly as potassium chloride and partly as lead chloride, and tending to increase slightly with increase in the melting temp. and, within limits, with increase in the amount of chloride added to the batch. The presence of potassium chloride in the batch greatly lessens the tendency of red lead to volatilize from the batch during the melting. Part of the alkali chloride added to the batch goes to increase the alkali oxide content of the glass. Up to about 1% of potassium chloride in the batch tended to decrease the melting rate slightly; between 2 and 4% potassium chloride caused an appreciable increase in the melting rate, while more than 4% gave irregular results. The presence of the chloride in solution lessened the tendency to waviness and improved the brightness of the glass. With increase in the potassium chloride content of the batch, the color of the glass became increasingly green, without undergoing any increase in iron content. D. J. McS.

The production of opalescence by chlorides in potash-lead oxide-silica glasses. E. M. FIRTH, F. W. HODKIN, AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **10** [38], 199–212 (1926).—Potash lead glasses similar to English crystal must contain at least .50% chlorine to develop opalescence on reheating, where chloride is the only opacifying agent present. Amount of chloride dissolved must evidently be increased somewhat to produce opalescence with increasing hardness of the glass. The opalescence appears only very slowly or not at all below 500°C; it develops most rapidly between 800–900°C and disappears when reheated above 1000°C. The glass containing chloride apparently showed a higher anneailng temp. than the same glasses without chloride. D. J. McS.

Glass furnace developments. THOMAS C. MOORSHEAD. *Ceram. Ind.*, **6** [6], 591–600 (1926).—A discussion of leers and furnaces. A description of the cyclone glass melting furnace which is a vertical conical furnace using tangential burners to give a cyclone or whirling flame at the top of the cone. An experimental plant will be built at the Carlton works of the United Glass Bottle Manufacturers, Ltd., to test this new type of glass melting furnace. F. P. H.

Why magnesia lime is preferable to a high calcium lime for glass. W. H. MEACHAM. *Ceram. Ind.*, **7** [1], 28 (1926).—The lime as used by the author consists of 57% CaO, 41% MgO and about .04% iron. The author states that the advantages of the high

magnesia lime are: (*a*) it does not powder as easily as high calcium lime, (*b*) it seems to enter into soln. more readily. The author advocates crushing the lime as required as it seems to have more life than that which has been stored for a period of time. F. P. H.

Fancy opaque glass. ANON. *Ceram. Ind.*, **7** [1], 32 (1926).—Fancy opaque glass is one of the modern art glasses. It is pressed, preblown hollow ware on which the contours of the preblown designs are opaque and the enclosed surfaces themselves are entirely transparent, or to reverse, the contours are transparent and the enclosed surfaces are opaque. The production of this type of art glass is described and a table showing batches of glasses for opaque designs in several shades is given. F. P. H.

Composition of glass determined by physical properties. ANON. *Ceram. Ind.*, **7** [1], 33 (1926).—The density and index of refraction of lime glasses are expressed as functions of the compn. Constants are given for each oxide found in this type of glasses which are to be substituted in the "partial density" equations. The density of the soda-silica series computed by the "partial density" method gave a max. variation of .43% from the observed values, while those computed by the Schott equation using the factors recommended by English and Turner gave a max. variation of 4.52%. F. P. H.

Conveyer and three men handle large glass bottle storage. ANON. *Ceram. Ind.*, **7** [2], 136 (1926).—Description of some of the equipment used at the plant of the Thatcher Mfg. Co. The glass machines, of which there are 2 to a tank, contain 16 molds on 2 tables and are run at the rate of 27 bottles per min. The melting temp. is 2500°F and the temp. of the glass in the molds is kept at 1950°F. It is necessary to keep the temp. of the glass at the feeder at as nearly a constant temp. as possible so that the production schedule could be maintained. F. P. H.

133⅓% output from glass tank. ANON. *Ceram. Ind.*, **7** [3], 240–43 (1926).—Description of equipment used at the Sheffield (Pa.) glass bottle plant. F. P. H.

The largest optical flat in the world. ANON. *Ceram. Ind.*, **7** [3], 243 (1926).—Three disks, or optical flats, have been produced by the Bur. Stand. and will be used as master flats for checking the accuracy of optical disks which are used in the work of the Bureau. Measurements on the surface of these 3 disks from 10 to 11 in. in diameter and 1½ in. thick, fail to show any places where they are more than two ten-millionths of an inch from being absolutely flat. These 3 optical flats are made from clean fused quartz or silica glass. In addition to serving as a test for flatness of surface and straightness of edge, these standards are used in the production of standard angles and for calibrating or checking instruments that measure curvature. F. P. H.

Preparation of machine made table glass. W. SCHMIDT. *Keram. Rund.*, **34**, 521–23 (1926). H. G. S.

The use of gas in the glass industry. D. OTTO. *Sprech.*, **59**, 475–76 (1926). H. G. S.

Melting investigations pertaining to the coloring of glass. L. SPRINGER. *Sprech.*, **59**, 530–31 (1926).—The effect of different coloring oxides upon the color of a glass composed of $50SiO_2$, $10CaCO_3$, and $30Na_2CO_3$ was investigated. 1 g. FeO produced a green glass; 1 g. Fe_2O_3 produced a glass of the same color; and 1 g. Fe_2O_3 and 2 gs. As produced a yellow-green color. Fe_2O_3 is reduced to FeO in melting except in the presence of As which acts as an oxidizing agent. 1 g. FeO, 2 gs. As and 2 g. KNO_3 produces a yellow green while 1 g. Fe_2O_3 and 2 gs. As produces a slightly colored glass which appears green. Likewise the effects of As, Ni, CoO, MnO_2, Se, S, C, Na_2SO_4, and NaCl upon the color of this glass are reported. H. G. S.

Fifty years of glass making. ALEXANDER SILVERMAN. *Ind. Eng. Chem.*, **18** [9], 896–99 (1926).—Developments during the past 50 years in the following phases of

the glass industry are traced and discussed: window glass; plate glass; bottles; electric bulbs; lighting and table ware; optical glass; chem. and cooking ware; treatment and decoration; furnaces and accessories; and calculations. The trend of the times toward specialization, consolidation, and introduction of automatic or semiautomatic machinery is mentioned. E. J. V.

A half-century of progress in the glass industry. GEORGE W. MOREY. *Ind. Eng. Chem.*, **18** [9], 943–45 (1926).—Early history of the glass industry is reviewed. The work resulting in the development of modern laboratory glassware, thermometer glass, optical glass, and present day commercial methods of glass production is traced and discussed. Advances in glass technology are mentioned. E. J. V.

The index of refraction of glass at high temperatures. C. G. PETERS. *Pottery Gaz.* **51** [591], 1406 (1926). (Abstract of Bur. of Stand., *Sci. Paper*, 521).—An interferometer method for measuring the index of refraction is explained. Measurements were made on the index of refraction and thermal expansion of 9 different samples of glass in the temp. region of 20° to 700°C. These showed that the glasses passed through a critical expansion region near 500°C in which the rate of expansion increased by 2 to 7 times. The index of refraction increased up to this critical region, decreased in the rapid expansion region, and increased again above the softening temp. E. J. V.

Annealing glass bulbs in a gas furnace. F. A. BECKER. *Pottery Gaz. and Glass Trade Rev.*, **51** [591], 1406 (1926). Reprinted from *Fuels and Fur.*, **4** [3], 357 (1926). See also *Ceram. Abs.*, **5** [5], 146 (1926). E. J. V.

Sand for glass polishing and sand blasting. W. M. WEIGEL. *Pottery Gaz. and Glass Trade Rev.*, **51** [591], 1407 (1926). Reprinted from *Nat. Glass Budget*, **42** [8], 11, 13 (1926). See also *Ceram. Abs.*, **5** [9], 268, 272 (1926). E. J. V.

One hundred and twelve years of glass making. ANON. *Glass Ind.*, **7** [9], 207–11 (1926).—An interesting account of the history of the Whitall Tatum Co. in Millville, N. J., founded in 1814 and still operating on its original site. The works and their equipment are described and the types of products of the concern are listed. E. J. V.

The composition of glasses which absorb ultra-violet rays. ANON. *Die Glashütte*, **56** [23], 444 (1926); *Glass Ind.* **7** [9], 212 (1926).—Data taken from the American patent literature show that glasses containing more than 5.0% of titanium oxide, 3.5% vanadium oxide, or 4.5% cerium and vanadium oxides have strong absorbing powers for ultra-violet rays and, in contrast with the German glasses, are colorless. Typical analyses and batch compositions are given. E. J. V.

Colorless glass production in tank furnaces. III. ARNOLD COUSEN AND W. E. S. TURNER. *Glass Ind.*, **7** [9], 213–15 (1926).—Experiments to determine the influence of arsenious oxide in decolorizing glass and tests on possible substitutes for it are discussed in detail. Results obtained show that arsenious oxide is a necessary factor in the decolorizing of glass by selenium, the actual amount required being influenced by the time and temp. of the glass melting. As a general rule, the minimum amount employed should be 30 times that of the selenium. Arsenious oxide itself acts as a decolorizer. Under the conditions of the test neither antimony oxide nor calcium phosphate would serve as a substitute for arsenious oxide in decolorizing glass. W. J. Rees and W. R. Dale mention results obtained by them which confirm the results obtained by the authors. E. J. V.

The valuation of zinc oxide. ANON. *Glass Ind.*, **7** [9], 218–19 (1926).—Properties of zinc glasses, forms in which zinc may be introduced into glass batches, technology of zinc oxide, qualitative, and quantitative analysis thereof are discussed. E. J. V.

Glass Container Association expands its service. ANON. *Glass Ind.*, **7** [9], 226 (1926).—An account of the July meeting of the Association in Atlantic City for the

purpose of discussing means of expanding service to its members and the financing of this service. E. J. V.

German table glass syndicate fails. DOUGLAS MILLER. *Amer. Glass Rev.*, **45** [47], 14 (1926); *Nat. Glass Budget*, **42** [17], 26 (1926).—Recent endeavors to establish a table glass syndicate in Germany have been unsuccessful and the prospects are dubious. If no agreement can be made, weaker producers may have difficulty in operg. due to keenness of competition. E. J. V.

New type glassware loader for continuous leers announced. ANON. *Amer. Glass Rev.*, **45** [47], 14 (1926).—The "Hemingray," fully automatic in operation, simple in design, and of a very rugged construction, is the new and efficient type of leer loader offered to the glassware industry by the Simpson Foundry & Engineering Co. of Newark, Ohio. E. J. V.

English glass news. ANON. *Amer. Glass Rev.*, **45** [47] (1926); *Nat. Glass Budget*, **42** [17], 12 (1926). Partially reprinted from *Pottery Gaz. and Glass Trade Rev.*—The effect of the coal strike on the glass industry, which is operating with great difficulty and at greatly increased production cost, is discussed. Experiments are being conducted at Stourbridge in the use of fuel oil for melting purposes. The effect on various branches of the industry is mentioned. E. J. V.

Recent developments in the Belgian glass industry are reviewed. WILLIAM C. BURDETT. *Amer. Glass Rev.*, **45** [47], 17 (1926); *Nat. Glass Budget*, **42** [16], 26 (1926); *Ceram. Abs.*, **5** [10], 304 (1926); *Glass Ind.*, **7** [9], 226 (1926). E. J. V.

Cheap natural gas helps glass making in Rumania. ANON. *Amer. Glass Rev.*, **45** [47], 18 (1926).—Rumanian glass industry has been growing and now has 10 hollow ware, 3 window glass, 2 bottle, and 10 cut glass and decorating plants and establishments. Impossibility of successful foreign competition with the cheap natural gas in Rumania leads to the belief that in a few years all glass products needed there will be of domestic manufacture. E. J. V.

Glass making in Jugoslavia. ANON. *Amer. Glass Rev.*, **45** [47], 23 (1926); *Nat. Glass Budget*, **42** [17], 17 (1926).—Glass manufacture in Jugoslavia is making slow progress. Six hollow ware, 3 window glass, 3 bottle, and 3 cut glass plants are active only a few days each week due to the general critical state of affairs. E. J. V.

Annealing of glass discussed in a non-technical article. A. N. FINN. *Amer. Glass Rev.*, **45** [47], 26 (1926).—Partial reprint from *Jour. Amer. Ceram. Soc.*, **9** [8], 493–500 (1926). See also *Ceram. Abs.*, **5** [10], 300 (1926). *Pottery, Brass and Glass Salesman*, **34** [7], 27 (1926). E. J. V.

British bottle makers organize. ANON. *Amer. Glass Rev.*, **45** [48], 27 (1926).—An announcement of the formation of the Glass Manufacturers' Federation and officers thereof is made. E. J. V.

Modern American glassware will have centenary in 1927. ANON. *Amer. Glass Rev.*, **45** [49], 23 (1926). (Reprinted from *Christian Science Monitor*).—The modern glassware industry was born in 1827 with the turning out of the first pressed-glass tumblers at Sandwich, Mass. The first appearance of articles in all branches of the industry in America is listed. E. J. V.

Research work of the Ceramic Division, Bureau of Standards, is summarized. GEORGE K. BURGESS. *Amer. Glass Rev.*, **45** [50], 15 (1926).—Brief summaries of the following investigations and activities pertinent to the glass industry are given: annealing of glass; specifications for table glassware; a non-actinic, cobalt-blue glass; tank control and devitrification; molding, annealing, and inspection of optical glass; study of tank blocks; American and German fireclay brick; routine production of refracs.; and manuf. of fireclay brick. E. J. V.

Australian glass industry growing rapidly. ANON. *Amer. Glass Rev.*, **45** [50], 17–18 (1926).—Data showing the growth of this infant industry of the Commonwealth are presented. E. J. V.

New process to increase use of plate glass for residences. ANON. *Amer. Glass Rev.*, **45** [50], 40 (1926). (Reprinted from *Patton's Monthly*).—The new process developed at the Creighton, Pa., plant of the Pittsburgh Plate Glass Co., is best adapted to the production of thin polished plate glass most suitable for glazing residences and the use of this commodity is expected to be materially accelerated. E. J. V.

Plate glass protects furniture. ANON. *Nat. Glass Budget*, **42** [17], 7 (1926). (Reprinted from *Kansas City, Mo., Journal.*)—Protection of polished furniture with plate glass covers cut to fit, use of glass behind elec. light switches, as shelving, window seat covering, etc., are discussed. E. J. V.

Britain's optical glass. ANON. *Nat. Glass Budget*, **42** [17], 12 (1926). (Reprinted from *Pottery Gazette and Glass Trade Rev.*)—Due to the emergencies brought on by the war, the optical glass manufacture has improved to such an extent that there are now 112 varieties of glass put on the market by one of the firms where prior to the war the only British producer made about 26 different types. Another problem solved is that of producing satisfactory "barium crown" glasses. Results of expts. are mentioned. The history of British achievements in optical glass work is traced briefly. E. J. V.

Notes on viscosity and devitrification of glass. J. W. CRUIKSHANK. *Nat. Glass Budget*, **42** [17], 13 (1926). Reprinted from *Bull. Amer. Ceram. Soc.*, **5** [8], 344–46 (1926). See also *Ceram. Abs.*, **5** [10], 300 (1926). E. J. V.

First Peruvian glass factory starts. GEORGE A. MAKINSON. *Nat. Glass Budget*, **42** [17], 17 (1926).—A modernly equipped glass plant located in the outskirts of Lima, having a potential capacity of 25 tons in 24 hrs., is in operation to only a fraction of its capacity and is limiting its output to bottles. Transportation difficulties make successful competition with imported glass doubtful except in the central provinces. E. J. V.

Italian glass industry improves. ANON. *Nat. Glass Budget*, **42** [17], 18 (1926).—Substitution of mech. for hand labor, use of improved mach. and intense activity in building have caused improvement in the glass industry of Italy. E. J. V.

Glass news of Hungary. ANON. *Nat. Glass Budget*, **42** [17], 26 (1926).—The glass industry, while not large, has been well employed. A small number of bottles was exported but other glass manufacture had to be imported. E. J. V.

Swedish glass industry slows up. ANON. *Nat. Glass Budget*, **42** [17], 26 (1926).—Foreign competition has placed the Swedish window glass industry in a precarious position and its survival is doubtful. Only 2 plants out of 12 in 1920 were working early in 1926. Labor conditions are discussed. E. J. V.

Suggested market for heavy window glass. ANON. *Nat. Glass Budget*, **42** [18], 9 (1926).—Heavy window glass may be utilized in many places in the home suggested as favorable places for the use of plate glass, and in the production of units suitable for making private hotbeds. E. J. V.

Can make a variety of bottles. ANON. *Nat. Glass Budget*, **42** [18], 14 (1926).—Mention is made of the development of glass blowing machinery to so great an extent that it is even possible to produce bottles of 8 different designs in one revolution provided the same amount of molten glass is contained in each. E. J. V.

Glass works centennial in Saint Lambert Valley. ANON. *Nat. Glass Budget*, **42** [19], 3 (1926); *Amer. Glass Rev.*, **45** [49], 30 (1926).—A résumé of the program followed during the centennial celebration of the Val. St. Lambert Glass Co. in Belgium. E. J. V.

Paper on the annealing of glass. ANON. *Nat. Glass Budget*, **42** [19], 19 (1926).—A note regarding A. N. Finn's paper in *Jour. Amer. Ceram. Soc.*, **9** [8], 493–500 (1926). E. J. V.

What molten glass will do. ANON. *Nat. Glass Budget*, **42** [20], 13 (1926). (Reprinted from *Alton, Ill., Telegraph.*) A description of damage caused by molten glass which passed beyond control of factory operators in a plant of the Illinois Glass Co. E. J. V.

New substitute for glass? E. E. FREE. *Nat. Glass Budget*, **42** [20], 16 (1926). (Reprinted from *Literary Digest.*) A description of "pollopas," produced by a chemical process out of formaldehyde and urea, invented by Fritz Pollak, an Austrian chemist. Its properties are compared with those of glass. E. J. V.

Manufacturers of plate, window, and other glass address jobbers' meeting at Chicago. ANON. *Nat. Glass Budget*, **42** [21], 3 (1926).—An account of the program followed at the first fall meeting of the western division of the National Glass Distributors' Association held Sept. 14, 1926. E. J. V.

Describes "strain" in glass. A. N. FINN. *Nat. Glass Budget*, **42** [21], 8 (1926). (Reprinted from *United States Daily*).—The app. used at the Bur. Stand. for determining the amount of strain in glass is described. The cause of strain in glass is explained non-technically, as is the method of removing it by annealing. E. J. V.

Baroni test for neutral glass. L. TIRELLI. *Boll. Chim. farm.*, **65**, 65–72 (1926); *Chem. and Ind.*, **45B**, 440 (1926).—For pharmaceutical, and particularly for hypodermic glass, Baroni suggests following test. A vessel of the glass is filled with distilled water and sealed and immersed in steam at 2 atmospheric pressure for 1 hr., and when cold reopened. The water should exhibit no pink or violet coloration within 24 hrs. after treating with 3–4% of its volumes of 1% alcoholic solution, freshly made, of crystallized haematoxylin. With silicate glasses, the reaction indicates solution of bases, like Cu, but not of neutral salts nor of acid oxides. With boric glasses, a negative reaction does not prove absence of attack. The phenolphthalein test should be used in addition to the haematoxylin test. H. H. S.

Determination of iron in red lead for glass manufacture. J. F. SACHER. *Farben-Ztg.*, **31**, 2131–32 (1926); *Chem. and Ind.*, **45B**, 631 (1926).—Crystal glass manufacturers demand red lead containing not more than 0.005% Fe. A standard method of analysis is advisable, and a system of air filtration is required owing to the iron content of dust in works. The most exact method is the colorimetric one with KCNS, the iron being in H_2SO_4 solution, not HCl. The presence of Bi is a disturbing factor. H. H. S.

Glass Research Association. ANON. *Nature*, **117**, 398 (1926).—The Glass Research Assn. Bulletin No. 14, issued 1925, supplies a résumé of work done by the Association. This work was carried on in the Association Laboratory in coöperation with the National Physical Lab., the Dept. of Glass Technology, Sheffield, and the British Refractories Research Assn., the British Cast Iron Research Assn., and in a single investigation of the subject of the efficiency of manual workers, with the Industrial Fatigue Research Board. Several papers are given on the physical properties of glasses, covering the subjects of viscosity, thermal endurance, and elastic and viscous movements in glass. Research on viscosity of glass covers a wide range of temps. and led to interesting results. Investigations of a series of problems of a fundamental character, involving the processes of glass-melting were carried out at Sheffield and results important for practice and theory were found. Future investigations may be pursued on the subject of the constitution of glasses, using such methods as the determination of viscosity, electrical properties or surface tension, the behavior of glass under electrolysis over a wide range of temp., a study of X-ray diffraction patterns, and of heating and cooling curves obtained under various conditions. Other subjects needing investigation as having more or less direct practical application include the mechanical properties of glass in relation both to composition and to treatment, the thermal properties of glass at all temps. up to melting temps. and the solubility of gases in glass at various temps.

and pressures, their mode of evolution and absorption, and their effect on the physical properties of the glass. O. P. R. O.

Hexagonal crystals found in devitrified glass. M. BELLIÈRE. *Ann. soc. geol. Belgique*, **47,** M41–50 (1925).—The crystals are of two types, spherolites and hexagonal groupings. In calcic-sodic devitrified glasses the spherolites are wollastonite; glasses poor in lime give tridymite and cristobalite. The hexagonal groupings are pseudo-wollastonite. (*C. A.*)

Progress in the glass-etching industry. W. H. *Keram. Rund.*, **33,** 544 (1925); *Jour. Soc. Glass Tech.* (Abs), **9,** 291–93 (1926).—HF and concentrated H_2SO_4 etch glass to a depth of 2 mm. Relief designs may be formed by drawing the design in printer's ink on paper, pasting on the glass surface, drying, and finally treating with 1.14 HF for 3 min. The reverse effect is obtained by transferring the pattern to the glass with an oil varnish, moistening, dusting with metal or copal powder, dipping in acid and rinsing. Fluorides of NH_4 and alkaline earth give less satisfactory results than HF. KHF in solution may be used for hollow ware, and a silky appearance obtained by further etching with 1 : 5 HF. One mixture for mat etching contained 250 g. powdered CaF_2, 250 g. concentrated HCl, and 140 g. of either K_2SO_4, $K_2C_2O_4$ or $ZnCl_2$ per l. Dilute acids give a bright surface; concentrated acids a deep, rough, uneven surface. A resistant ground for sand blasting may consist of 50 g. lightly soaked gelatin, 50 cc of 25° $ZnCl_2$, 50 cc of 25° glycerol, and 250 g. Swedish lamp black; or 10 parts linseed oil, 1 part turpentine, 2 parts amber varnish and sufficient talc for a good cement. For the production of colored lacquers a protective coating of 30 parts wax, resin, and rubber (dissolved in turpentine) 100 parts turpentine, 50 parts varnish, 25 parts colophony, 600 parts asphalt, and 60 parts talc may be used. For incandescent lamp shades a sand blast or hot 5% HF is used. One etching bath contains 10 parts K_2SO_4, HF and HCl, 20 parts KF and 40 parts H_2O. For etching printing on glass the surface must be dry and the ink pure. The paper is drawn through a solution of 100 g. NaCl, 150 g. alum and 4 l. of H_2O, drained, dried and brushed twice with a cold solution of 250 g. glue, 100 g. glycerol, and 25 g. NaCl in 1000 cc H_2O. The best ink is 150 g. French turpentine, 60 g. Syrian asphalt powder, 50 g. yellow beeswax and 30 g. Burgundy resin. Remove paper with acid or alc. For printing in relief cover the articles with Sn foil cemented on with asphalt. The foil is less attacked by the acid than the glass. Photomechanical etching is produced by coating the glass with gelatin sensitized with $K_2Cr_2O_7$. After exposure, dust over with cryolite powder which adheres only to the protected areas. An etching ink may be made from equal parts HF, NH_4F and $BaSO_4$ ground together. Store in a gutta-percha bottle. (*C. A.*)

Glass casings. W. H. DIAMANT **47,** 544 (1925); *Jour. Soc. Glass Tech.* (Abs.),**9,** 260. For a transparent casing use 100 parts sand, 35 Pb_3O_4, 5 K_2CO_3, 3 KNO_3, and $Na_2B_4O_7$, and 20 parts good crystal glass; for an opaque casing replace KNO_3 and borax with 4 parts SnO_2 and 1.5 parts As_2O_3. The best opalescent casing for an ordinary sulphate glass is determined only by experiment. With a base consisting of 480 kg. sand, 178 lime, 183 sulphate, 12.75 coke, and 3 soda, the casing contained 45 kg. sand, 8.5 soda, 3 potash, 4 cryolite, 10 feldspar, 4.5 CaF_2 and 0.2 MnO_2. Another was 100 kg. sand, 28 soda, 12 of 80–85% potash and 16 calcite. Blended opal and colored articles may be made from an opal base containing 100 parts sand, 26 soda, 10 limestone, 18 feldspar, 8 cryolite and CaF_2 (NiO as decolorizer) and red casing of 100 kg. sand, 18 soda, 16 potash, 4 borax, 10 limestone, 2 SnO_2, 4 Cu_2O and 1.5 Fe_2O_3 and MnO_2. An aquamarine casing contained 85 parts sand, 20 soda, 10 potash, 15 $CaCO_3$, 2.5 kg. $CuSO_4 \cdot 5H_2O$ and 75 g. Co_3O_4; for light green color, with 1.5 kg. K_2CrO_4, and 2.5 kg. CuO; for deep blue with 5.5 kg. CuO and 50 g. Co_3O_4; for green 3.5 kg. $BaCrO_4$ and 1 kg. K_2CrO_4. Gold iridescence is produced by a thin inner layer colored yellow with Ag and another layer of mother-of-pearl, opal, or crystal glass. The silver glass was: 100 parts sand, 80 Pb_3O_4.

10 borax, 30 potash and 0.5 Ag_2O. A patented brilliant glass is produced from an Ag glass by surface reduction to the metallic state. (*C. A.*)

Unbreakable glass. H. KÜHL. *Glashütte*, **55**, 365–87 (1925); *Jour. Soc. Glass Tech.* (Abs.), **9**, 186 (1926).—This is a study of the effect of the different oxides on the resisting properties of the Pyrex-type glass. If sand, borax and kaolin are used for the batch an excellent glass is obtained but one which requires an abnormally hot furnace for proper melting. When sand 50, phonolite ("Clickstone") 100, and borax are substituted the fusion is easier but the product is dark green and contains both CaO and MgO. Sand, $BaCO_3$, borax, and kaolin produce a more fusible but quite stable glass. (*C. A.*)

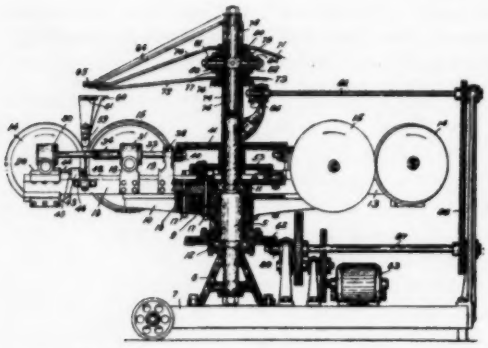
Physical properties of glass related to their composition. II. Mechanical properties. G. GEHLHOFF AND M. THOMAS. *Z. tech. Physik* **7**, 105–26 (1926).—The density of glass species with increasing percentage of $Na_2O \cdot K_2O$, MgO, CaO, ZnO, BaO, Al_2O_3, Fe_2O_3, PbO, and B_2O_3 is a linear function of the percentage only for ZnO, BaO, Al_2O_3, and Fe_2O_3; no singular point in density curve was found for mixed Na-K glasses of varying ratios. The tensile strength *P* was determined; it depends upon the relative size of the smooth part of the fracture. The values given are interpolated for a 10% size. The glass was previously annealed, although the influence of internal stress or "firepolish" was rather small. *P* is raised by substituents in the decreasing order CaO, B_2O_3 (up to 15%), BaO, Al_2O_3, PbO, K_2O, Na_2O, SiO_2, MgO, ZnO, Fe_2O_3; the last four have little influence; CaO and BaO have a maximum at about 25%. The *P* values found vary between 4.5 and 6 kg./sq. mm.; they are the largest for B_2O_3 and CaO glasses, 7 kg./sq. mm. The bending strength *F* was determined on glass rods, considered to be elliptical in section. It decreases slightly with increasing size of the section (Bach); the values are reduced to a 40 sq. mm. value of the section; no influence of firepolish was noticed. The influence for small percentages was in the order CaO, BaO, PbO, ZnO, MgO, B_2O_3, Fe_2O_3, SiO_2, Al_2O_3. The alkali metals raise *F* at sharply increasing rate. The bivalent metals except MgO, show maxima between 15 and 20%. Al_2O_3 lowers *F*. The values determined lie between 1.0 and 2.0 kg./sq. mm. The compressive strength *C* (up to explosive pulverization) was lowered by almost all substituents in the order Al_2O_3 (slight increase), SiO_2, MgO, ZnO, B_2O_3, Fe_2O_3, BaO, CaO, PbO, Na_2O, K_2O (sharp decrease), the values range between 70 and 100 k g./sq. mm. No proportionality between *P* and *C* was found. The brittleness *S* was measured as energy per cc necessary for crushing by impact. A special instrument was used in which a pendulum with attached wt. knocked against the flat side of a 5 x 1.5 x 0.2-cm. glass plate; deviations of 30% were sometimes obtained. The firepolish has a large influence. Etching of the glass surface raises *S* over 40%. The influence of alkali metals present in the glass was a slight positive one, bivalent metals are uncertain, B_2O_3 gives a strong increase up to 15% with maximum (3.5 m. kg. 10^{-3}) while Al_2O_3 gives a slight increase; the values lie around 2m. kg. 10^{-3}. The hardness *H* was determined with a Martens app. (diamond under 20-g. load, figures given in reciprocal breadth of the scratch) after removal of the surface layer. Alkali metals lowered *H;* mixed additions of K and Na produced a minimum *H* for an intermediate composition (10% Na, 5% K). At this same composition the minimum annealing temp. was lowest. MgO, ZnO and BaO raise *H;* it is slightly lowered by PbO, raised by B_2O_3 with a maximum for 15% B_2O_3; Al_2O_3 and Fe_2O_3 cause a slight increase. The values of *H* are between 150 and 250 per mm.; the latter value is the one for 15% B_2O_3 and for 30% ZnO. The modulus of elasticity *E* goes down with K and Na, slightly up with BaO, PbO, ZnO, MgO, Al_2O_3, and Fe_2O_3. It is increased sharply by CaO and B_2O_3; the values found are around 6500 kg./sq. mm., best values 9000 for 15% B_2O_3 and 10,000 for 20% CaO. Tables are

given for the increase of most of these properties per cent addition of each component. (*C. A.*)

BOOK

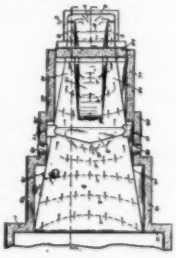
Practical Glass Manipulation. D. B. BRIGGS. London: Crosby, Lockwood and Son. 39 pp. 2*s* 6*d*. Reviewed in *Chem. and Ind.*, **45**, 428 (1926). (*C. A.*)

PATENTS



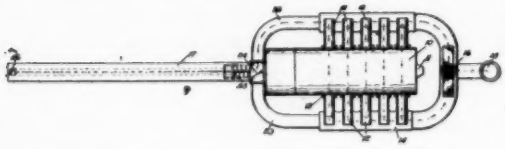
Machine for forming spherical bodies. H. M. JENKINS. U. S. 1,596,879, Aug. 24, 1926. In a machine for making spherical bodies, multiple pairs of rotating, grooved, coöperating, forming members, means for causing the pairs to move in succession past a receiving station and means for separating the members of each pair to discharge finished material therefrom and for returning the members to working position thereafter.

Glass furnace. J. T. KEENAN. U. S. 1,597,073, Aug. 24, 1926. In an apparatus of the class described, the combination of a main furnace comprising a glass melting tank and a refining tank, an auxiliary feed tank in communication therewith having a discharge opening above the normal glass level therein, a displacer, means to reciprocate the displacer in auxiliary tank to thereby displace the molten glass therein and cause it to discharge through discharge outlet, the walls of auxiliary tank being sloped inwardly above the normal level of the molten glass thereby to effect an accelerated displacement of the glass upon reciprocation of displacer.



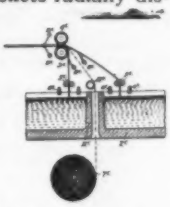
Continuous tank furnace. E. T. FERNGREN. U. S. 1,597,440, Aug. 24, 1926. A continuous tank furnace for supplying molten glass to sheet-glass machines, comprising a melting tank, a relatively small and shallow pot from which the sheet is drawn, and a refining and cooling tank connecting the melting tank and pot, the side walls of the refining tank converging progressively from the relatively large delivery opening in the melting tank to the relatively narrow open end of the pot.

Means for heating an annealing leer and process of annealing. G. J. RICE. U. S. 1,597,481, Aug. 24, 1926. In sheet glass drawing apparatus, a tank furnace, means for drawing a sheet, an annealing leer, and means for heating the annealing leer comprising means for absorbing heat from the exhaust gases from furnace, means to pass air in proximity to the heat absorbing means to heat the same, and means to pass the thus treated air through the annealing leer.



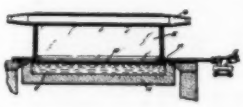
Glass-drawing apparatus. G. G. ROBERTS. U. S. 1,597,543, Aug. 24, 1926. A glass-drawing crucible of substantially elliptical form in horizontal section having its end-walls undercut, *i. e.*, inclined outwardly toward the ends of the crucible, said end-walls each being provided with a central vertical groove, for the purpose set forth.

Glass-blowing machine. W. D. MORRISON. U. S. 1,597,612, Aug. 24, 1926. In glass blowing machines the combination therewith of at least one pattern and finishing mold arranged radially and in sets upon a rotating table, a superposed intermittently operated rotable feed table, provided with a number of receiving pockets radially disposed in sets, each set corresponding in number to each set of pattern molds on the mold table, a feed tank, a plurality of feeding orifices from the tank, an automatically operating sliding bar positioned below the feeding orifices and fitted to the feeding table, and receiving cups disposed in a radial casing below the sliding bar, the cups delivering globules into the receiving orifices of the pattern molds.

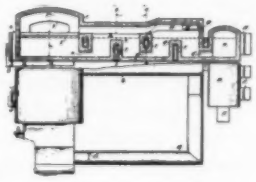


Manufacture of sheet and wire glass. C. P. BYRNES. U. S. 1,597,953, Aug. 31, 1926. In the manuf. of sheet glass, the steps consisting of drawing a sheet vertically from a glass bath, engaging it by opposed rolling surfaces while traveling vertically, and then deflecting it into a path at an angle to both the vertical and the horizontal.

Method and apparatus for annealing and cooling sheet glass. W. L. MONRO. U. S. 1,597,994, Aug. 31, 1926. In the method of annealing and cooling sheet glass, the steps consisting of passing flat hot glass through a leer tunnel in one direction, and causing gaseous fluid initially cooler than the glass to travel through substantially the entire length of the tunnel in the opposite direction, and in contact with the glass, substantially as described. Apparatus for annealing and cooling sheet glass, including a leer tunnel, means for passing glass therethrough in one direction, and means for causing gaseous fluid to travel through the tunnel in the other direction in streams on each side of the glass, substantially as described.



Sheet-glass-drawing apparatus. E. T. FERNGREN. U. S. 1,598,073, Aug. 31, 1926. In the art of drawing sheet glass, the method of producing a flat sheet consisting in drawing the sheet from a surface cooled supply of molten glass without restraint except adjacent the border portions of the sheet where the drawn portion of the supplying glass is tapered off laterally to the desired edge thickness while being mechanically restrained from advancement in the line of draw.



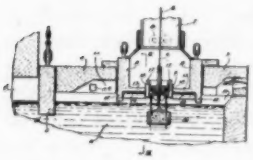
Apparatus for melting and fining glass. R. D. PIKE. U. S. 1,598,307, Aug. 31, 1926. An app. for melting and fining glass comprising an open-hearth regenerative fur. whose dimension longitudinally of the flame is greater than its dimension transverse thereto, a submerged port leading from furnace, a fining compartment connected with said submerged port to receive melted glass continuously from the furnace, means in fining compartment for mixing the constituents of the melted glass and removing therefrom the gaseous products of decomposition and a working chamber into which the glass is continuously delivered from fining compartment.

Method of and apparatus for fining glass. R. D. PIKE. U. S. 1,598,308, Aug. 31, 1926. A method of fining glass, which consists in passing the melted glass through a vacuum chamber and applying heat to chamber to maintain the temp. of the glass. The combination with a glass tank furnace of a vacuum chamber connected therewith and through which the glass is passed for the purpose of fining, and electrical heating means to maintain the temp. of the glass while passing through chamber.

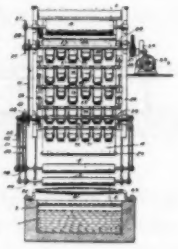
Glass-working machine. J. S. MOORE. U. S. 1,598,651, Sept. 7, 1926. In a glass-working machine having a table for blowmolds, an air supply which includes means

actuated by fluid pressure for intermittently moving the table and other means for locking the table between its intermittent movements, a casing, a control valve in the casing, said valve comprising end heads and a central head carried within a casing of greater length than the distance between the end heads, said casing having a longitudinal way provided with end ports and a central port, means between the end and central ports for reducing the area of a portion of the longitudinal way, exit openings adapted to be alternately closed by the extreme ends of the control valve, and ports which are placed alternately in communication with pipes through which fluid pressure is supplied to actuate the table moving and the locking table means.

Apparatus for surfacing sheets or plates. H. K. HITCHCOCK. U. S. 1,598,720, Sept. 7, 1926. The combination with a circular driven surfacing table, of means for supporting thereabove a series of sheets of material to be surfaced, and carrier means for giving such means a movement of translation to the table, then circumferentially thereof and finally away from the table.



Apparatus for making sheet glass. W. G. KOUPAL AND J. S. GREGORIUS. U. S. 1,598,729, Sept. 7, 1926. The combination with a glass tank, having a refractory top spaced above the glass with a drawing opening therethrough and sheet drawing means for drawing a sheet upward from the bath with its line of generation lying transversely of the tank, of a refractory block extending transversely of the tank on each side of the drawing opening and having its lower edge extending down below said top to a level adjacent the surface of the glass bath in the tank, the said bottom edge of each block being bowed down so that it is closer to the bath at the central portion thereof than at the edges.



Apparatus for drawing sheet glass. H. G. SLINGLUFF. U. S. 1,598,751, Sept. 7, 1926. In glass drawing apparatus for drawing a sheet or ribbon continuously from a bath of molten glass, a pair of vertical opposing endless insulating curtains spaced above the bath adapted to receive the sheet and contact with it while the glass is dropping in temp. from that below the setting point to a point at which the glass may be cracked off, and opposing driven rollers between the curtains and the glass for applying drawing force to the sheet.

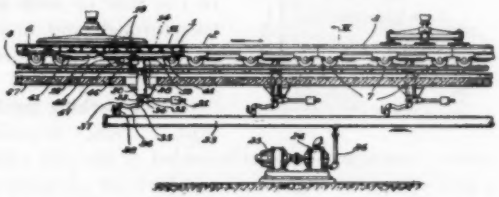
Apparatus for surfacing glass and the like. A. E. EVANS. U. S. 1,598,763, Sept. 7, 1926. In combination in a surfacing machine a framework, a vertical casing carrying at its upper end an annular gear casing, a pair of links pivoted to the framework and to the casings and serving to guide the casings vertically, means for counterbalancing one of the links, a drive spindle journaled in the vertical casing and carrying a surfacing runner at its lower end, a motor mounted on the annular casing, with its drive shaft in vertical position in alinement with spindle, and reducing gearing in annular gear casing between the drive shaft of the motor and the upper end of spindle.

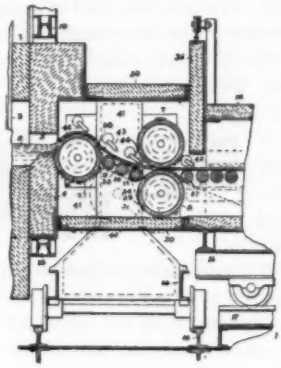
Apparatus for making sheet glass. J. H. FOX AND H. F. HITNER. U. S. 1,598,764, Sept. 7, 1926. The combination with a glass drawing tank, of a draw-bar of refractory material extending transversely of the tank submerged below the surface of the glass and provided on its upper side with a longitudinal groove, a molten metal lying in groove, and means for causing a flow of electric current through molten metal to heat the glass lying above the draw-bar.

Process and apparatus for drawing sheet glass. J. H. FOX AND H. F. HITNER. U. S. 1,598,765, Sept. 7, 1926. A process of drawing glass, which consists in drawing a sheet

upwardly from a molten bath, and passing a flow of electric current through the bath so that the major portion thereof flows through the layer of glass at the surface of the bath from which the sheet is drawn.

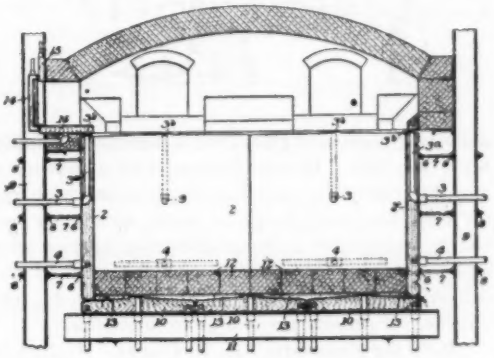
Apparatus for holding plates or sheets upon surfacing tables. J. H. Fox. U. S. 1,598,766, Sept. 7, 1926. The combination with a surfacing car or table mounted for movement along a track and having a glass supporting surface, an exhausting chamber having communication with such surface provided with an outlet having a check valve, a vacuum terminal or intake member mounted adjacent the path of movement of the table and adapted to register with outlet as the table moves past it, means for applying suction to member, a valve for member, and means for opening valve when member is brought into registration with outlet.

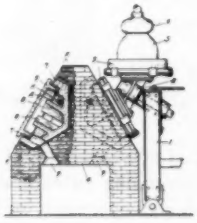




Apparatus for making sheet glass. Frederick Gelstharp. U. S. 1,598,770, Sept. 7, 1926. In apparatus for making sheet glass, the combination with a tank or receptacle for molten glass provided with an outlet through one of its side walls at the level of the body of glass in the tank, of a feed roll lying across the outlet and lying partly above and partly below the level of the glass in the tank, means for rotating the roll to feed the glass from the outlet and up over such roll in continuous sheet or ribbon, rolling means in advance of roll for engaging the glass sheet while still plastic and reducing it to uniform thickness, and a leer in advance of rolling means for annealing the glass sheet.

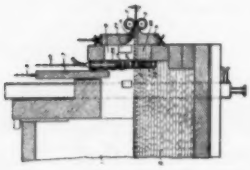
Glass furnace. C. D. McArthur. U. S. 1,598,779, Sept. 7, 1926. A glass tank furnace having a bottom formed of refractory blocks seated upon a series of hollow water-cooled members, members being independent of each other and separately removable, substantially as described.





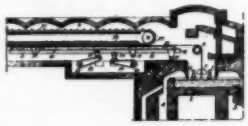
Furnace for heating glass-drawing pots. F. A. Ost. U. S. 1,598,782, Sept. 7, 1926. In a furnace of the character described, a removable combustion-chamber having its closed end cone-shaped, baffles in combustion-chamber, burners entering the sides of combustion-chamber for admitting a combustible fuel against baffles, whereby the firing fuel is given a circular motion.

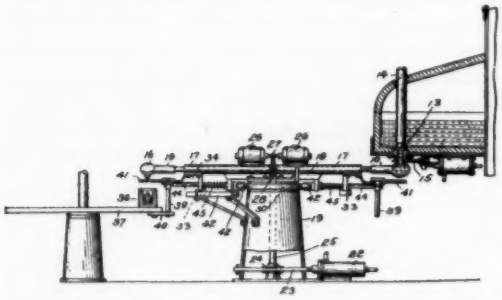
Gate for glass tanks. J. E. SWEET. U. S. 1,598,789, Sept. 7, 1926. The combination with a melting tank having an outlet opening at its forward end, of a water-cooled metal gate member to the rear of such outlet opening having an opening therethrough and mounted for vertical movement, and a movable water-cooled section closing opening and mounted for vertical movement in gate member.



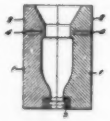
Glass-working machine. J. S. MOORE. U. S. 1,599,182, Sept. 7, 1926. A parison transfer for glass working machines comprising an arm provided at one end with a downwardly extending portion, a pair of parison engaging jaws which are pivotally attached to downwardly extending portion of the arm, a member attached to the arm to extend upwardly and over downwardly extending portion of the arm, a cylinder attached to member, a piston having a piston rod connected with the jaws, a casing for a control valve attached to the arm, means depending from the casing for unseating valves to control the movement of the piston connected with the jaws, and oscillatory frame which engages the arm, and pneumatically controlled means for raising and lowering the arm.

Method and apparatus for making sheet glass. H. F. CLARK. U. S. 1,599,647, Sept. 14, 1926. Apparatus for making sheet glass, including a tunnel through which drawn glass is adapted to travel, a plurality of bars extending along the direction of travel of the glass, and means for imparting to spaced points on the bars similar orbital movements whereby the bars are at times in contact and are moving with the glass and at other times are out of contact with the glass and moving in an opposite direction, certain of the bars being out of time with other of the bars, the mechanism being arranged to maintain the glass in substantially one plane during its movement along the bars.





Method of and apparatus for delivering masses of glass from a furnace to a mold. C. H. RANKIN. U. S. 1,599,790, Sept. 14, 1926. In combination with a moving mold and a glass-feeding device, a movable punty-like member for receiving a charge of molten glass from device and for delivering the charge to mold, means for moving member from a charge-receiving to a charge-delivering position with relation to the mold, and for moving the member with the mold to maintain the charge in a delivering position with relation to the mold, and shears moving with member for serving the charge from member.

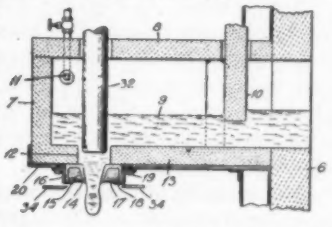


Mold for glassware. K. E. PEILER. U. S. 1,600,195, Sept. 14, 1926. A mold for glassware comprising a body portion, a funnel associated therewith, and means for cooling funnel.

Mechanism for transferring ware to leers. M. J. OWENS. U. S. 1,600,483, Sept. 21, 1926. Mechanism for conveying bottles or other glass articles comprising an endless conveyer, rolls mounted to rotate on horizontal axes and over which conveyer runs, and holders on conveyers running around axes and shaped to receive and hold articles in an

upright position on the upper lead of the conveyer with the articles projecting upwardly from the conveyer, the holders arranged to discharge the articles as they run over one of rolls.

Means for transferring and guiding glass into molds. J. F. RULE. U. S. 1,600,488, Sept. 21, 1926. The combination with means for forming gobs of molten glass of a continuously rotating mold table, molds thereon brought successively to charging position beneath the gob-forming means, guides moving about a stationary axis in a circular path eccentric to and overlapping that of the molds, and means to impart to the guides while within range of the molds, a radial movement without interrupting their movement about said axis, to thereby cause the guides to register with the molds during an extended portion of their movement, guides while in register with the molds being beneath gob forming means in position to direct the gobs into the molds.



Apparatus for discharging molten glass. K. E. PEILER. U. S. 1,600,962, Sept. 21, 1926. In apparatus for separating molten glass into mold charges, a container for the glass provided with a refractory discharge nozzle and an insulating jacket around and extending approximately to the discharge end of the nozzle to conserve the heat of the discharging glass.

Heavy Clay Products

Some sources of air in clay columns. S. L. GALPIN. *Jour. Amer. Ceram. Soc.*, **9** [9], 587–89 (1926).—Absorbed gases are of considerable importance as sources of air in clay columns. A few measurements are reported, and inferences drawn thereon.

Efficient drying and elimination of waste in the manufacture of sewer pipe. CHARLES A. MILLAR. *Bull. Amer. Ceram. Soc.*, **5** [9], 361–63 (1926).—M. presents ideas for improvements in sewer pipe plants. Boiler rooms and heat distributing fans should be in a building separate from the main building to obtain efficient drying. Methods for preventing roof drip, eliminating smoke, overcoming loss of exhaust steam, improving boiler of efficiency by installation of a water softening system and overcoming loss due to falling stands in a kiln are enumerated and discussed. Ways of disposing of broken pipe to eliminate waste are mentioned. E. J. V.

Test structural materials; aims to make houses safer. ANON. *Nat. Glass Budget*, **42** [21], 21 (1926). (Reprinted from *United States Daily*).—A general discussion of investigations and tests on structural mats. being conducted by the Bureau of Standards at Washington. E. J. V.

Influence of method of preparing specimens upon the compressive strength of sand lime brick. J. DITTMER. *Tonind. Ztg.*, **50**, 606–607 (1926).—D. discusses the effects of methods of preparing and storing sand lime brick upon their compressive strength. H. G. S.

The clay and heavy clay products industry of Westerwalde. G. SCHNEIDER. *Tonind. Ztg.*, **50**, 996–97 (1926). H. G. S.

The drying of brick. P. THOR. *Tonind. Ztg.*, **50**, 1099–1100 (1926).—T. emphasizes the importance of making humidity readings in different portions of the drier and describes a simple apparatus for measuring this. H. G. S.

Defects on brick and their prevention. B. PINKL. *Ziegelwelt*, **57**, 464–66 (1926).—P. discusses defects on brick made with the auger machine and suggests methods of preventing these. H. G. S.

Strength of tile walls. ANON. *Can. Eng.*, **51** [3], 153 (1926).—Reference to recent Bur. Stand., *Bulletin* prepared by Stang, Parsons, and Foster. The strength of 70 hollow tile walls, 6 ft. long, 9 ft. high, and 8 or 12 in. thick were tested under different conditions. End and side construction walls with centric compressive, eccentric, and transverse loadings were tested with the use of 4 classes of mortar. The mortar appeared to be the most important factor affecting the compressive strength. The data supply a basis for establishing specifications and building regulations for tile wall construction. E. E. P.

Tunnel kilns. C. FORREST TEFFT. *The Clay-Worker*, **85** [6], 466–68 (1926).—Discussion of the application of the tunnel kiln for firing face brick. A kiln must be designed to fit the conditions. Two important factors to be considered are: How fast can the ware be heated up and what is the vitrification range that will give satisfactory colors without overfiring. Curves are given showing actual present schedule on shale face brick plants. The cost of operating tunnel kilns is compared to that required for periodic kilns. F. P. H.

The evolution of brick and brickmaking in the United States. GEORGE M. FISKE. *The Clay-Worker*, **85** [6], 470–73 (1926).—This is the 4th of a series of articles dealing with the progress of the art of brickmaking during the last half century. F. P. H.

The march of progress in brickmaking typified by the plants of the Claycraft Mining and Brick Co. ANON. *The Clay-Worker*, **85** [6], 482–86 (1926). F. P. H.

A unique use of clay products. ANON. *The Clay-Worker*, **86** [1], 19–23 (1926).—An outdoors "Way of the Cross" built of clay products near Allegany, N. Y., beautifully landscaped and artistically arranged which will emphasize the adaptability of fired clay for generations to come. F. P. H.

De-airing as corrective in drying. FRED BRAND. *The Clay-Worker*, **86** [1], 40 (1925). Reprinted from *Jour. Amer. Ceram. Soc.*, **9** [4], 189–93 (1926). Abstracted in *Ceram. Abs.*, **5** [7], 214 (1926). F. P. H.

The evolution of brickmaking in the United States. GEORGE M. FISKE. *The Clay-Worker*, **86** [2], 118–23 (1926).—The 5th article in a series of articles dealing with the progress of the art of brickmaking during the last half century. (See above) F. P. H.

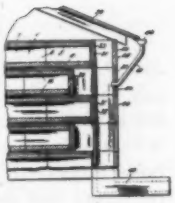
Making brick in South Africa. ANON. *The Clay-Worker*, **86** [2], 118 (1926).—Description of equipment and methods used at the Caronation Brick and Tile Co., located at Durban, Natal, South Africa. F. P. H.

Brick and tile industry. ANON. Manitoba Industrial Development Board, 1926.—There are 2 sources of materials in Manitoba for the brick and tile industries; the surface clays and the cretaceous shales and clays. Surface clays have been more extensively used than the under clays, and are the exclusive raw materials at the present time. Ample raw material is available for common brick, and there are indications that nearly all of the demands in face brick will be supplied within the Province. Progress has been made in meeting the demand for tapestry brick by mixing clays in the Province; further progress is possible by preheating the under clays. Cretaceous shales are used for sewerpipe and vitrified brick. Refractory clays for firebrick and pottery ware have been found in Manitoba only in a limited occurrence of kaolin on Little Deer Island, Lake Winnipeg. O. P. R. O.

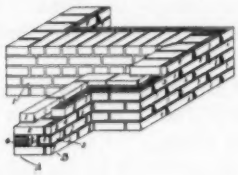
BOOK

Handbuch der Ziegel-Fabrication. 3rd Ed. KARL DÜMMLER AND DR. LOESER. 537 pp., 598 illustrations, published by Wilhelm Knapp, Halle. Reviewed in *The Clay-Worker*, **86** [1], 23 (1926). F. P. H.

PATENTS



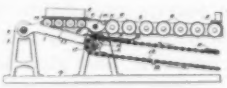
Building tile and wall construction. J. A. O'DONNELL. U. S. 1,597,104, Aug. 24, 1926. In a building structure, course tiles laid in courses, and corner tiles of exterior contour corresponding to the course tiles laid alternately at angles at the corners of the structure and having vertical spaces, the spaces of the overlapping ends of the corner tiles being in alinement whereby to provide a vertical passage throughout the height of the structure, and a drain at the lower end of the passage.



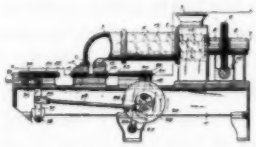
Building-wall structure. W. D. RICHARDSON. U. S. 1,597,110, Aug. 24, 1926. A wall structure comprising a burden bearing unit formed of alternate courses of headers and stretchers of standard size, a parallel facing unit formed in part of standard-sized facing bricks positioned between the header courses of burden bearing unit and formed in part with courses of narrower facing bricks bonded to the ends of the headers of the burden bearing unit by the standard-sized courses of facing bricks.

Brick-handling device. D. J. STRICKLAND. U. S. 1,597,118, Aug. 24, 1926. In a machine of the kind described, the combination with means for moving a filled mold from beneath a die, of means for striking the ends of mold, means for inserting mold with pallet, and a vertically movable guide in advance of inverter.

Brick-dumping apparatus. D. J. STRICKLAND. U. S. 1,597,119, Aug. 24, 1926. In a machine of the kind described, the combination with a main frame having a vertical tower, of a reciprocating carriage movable in frame, a mold pusher and a mold advancer connected to carriage, a mold inverter operable from the carriage and means for raising the molds and lowering the pallets and means for lowering the molds.



Brick machine. MIKE FARKAS. U. S. 1,597,961, Aug. 31, 1926. In a brick machine, the combination of spaced gravity conveyers having friction rolls and with their front sections pivoted so as to be capable of being raised and lowered, pivoted spaced dumpers capable of being swung downwardly and upwardly and passing between conveyers, and means for automatically delivering empty pallets upon dumpers.



Machine for plastic-clay working. J. E. BICKNELL AND F. C. H. MÜLLER. U. S. 1,599,274, Sept. 7, 1926. In an apparatus of the class described, a hopper having continuously rotating means therein for disintegrating pulverulent material, a cylindrical chamber adjacent hopper, a continuously operating screw located within chamber and having a sufficient clearance between itself and the walls of cylindrical chamber to permit a passage of the disintegrated pulverulent material under pressure, a mold adapted to receive the material from chamber while still under pressure, a plunger to travel against the material and separate it from the material being worked, an opposite die for completing the molding of the article, means to retract the last-named die and means to eject the article from the mold.

Auger machine. R. H. MCELROY, A. G. LANGENKAMP, AND JOSEPH CITE. U. S. 1,599,663, Sept. 14, 1926. In a combined pug mill and auger, a support, a pug mill tub, an auger casing, pug mill blades on a main shaft, a main shaft, an auger on main shaft working in the auger casing and pug mill blades adjacent the inner end of the auger set a greater angle than the removing blades to increase the impetus common to the pug mill and in the auger at the point where the special blades are located.

Refractories

Fusion points of firebrick-coal-ash mixtures. L. C. HEWITT. *Jour. Amer. Ceram. Soc.*, **9** [9], 575–82 (1926).—Six types of refractory brick were tested with 5 types of coal ash, the cone fusion points of the brick-ash mixture being determined over a range of 10% brick, 90% ash, to 40% brick, 60% ash. A departure was made from previous methods in that high ash mixtures were studied rather than high brick mixtures, in the belief that boiler slags contain a relatively low proportion of the refractory. Sintered mixtures of refractory and ash tend to give higher fusion points than the raw mixtures do. Any determinations made in an uncontrolled atmosphere are exceedingly unreliable. The results obtained in this investigation indicate that the "cone-slag test" is of very limited value as a means of selecting refractories for boiler service.

A comparison of the uniformity of strength and texture of fire brick made by different processes. A. E. R. WESTMAN AND W. H. PFEIFFER. *Jour. Amer. Ceram. Soc.*, **9** [9], 626–32 (1926).—By assuming that the "deviations from the average" of the strengths and permeabilities of individual bricks of any one brand are governed by the laws of chance, a comparison of the uniformity of strength and texture of a number of brands of brick made by different processes is obtained. Of the brands examined those made by the stiff-mud process are found to be more uniform in strength and less uniform in structure than those made by the dry-press process. The hand-made bricks show quite a variation in both strength and texture, whereas one brand of brick made by a semidry process (English type machine) shows good uniformity in both strength and texture.

A note on some factors governing the resistance of pots to glass attack. J. F. HYSLOP. *Jour. Soc. Glass Tech.*, **10**, [38], 148–52 (1926).—X-ray diffraction patterns of sections of 2 series of pots which had been used against the same glass, and of which one series gave exceptionally long life, while the life of the other series was much shorter although still satisfactory, showed that the body of the used pots consisted essentially of mullite, cristobalite, and tridymite. The porcelain layer adjacent to the glass in the better series of pots was very thin and uniform in thickness, and consisted of mullite, cristobalite, and glass when slowly cooled, but when annealed at 1350°C and water quenched, the silica remained in solution in the glass and the X-ray pattern showed only mullite. The porcelain layer from the poorer series of pots was much thicker and more irregular and showed only mullite and glass when slowly cooled, indicating that the slower attack on the better series of pots might have been due to the glassy portions of the porcelain layers of this series being more highly siliceous than that of the poorer series. D. J. McS.

Refractory materials for the glass industry. A general discussion. ANON. *Jour. Soc. Glass Tech.*, **10** [38], 161–70 (1926).—E. A. Coad-Pryor gave examples illustrating the difficulty of drawing definite conclusions from the results of laboratory and large scale practical corrosion tests on refractory blocks. Failure of blocks through insufficient firing not as common now as formerly, but failure through the presence of molding defects still common. He suggested the possibility of detecting holes in blocks through X-ray examn. W. J. Rees suggested that formation of fine fissures in block may be due to strains set up in drying, and that elimination of holes might be effected by casting the blocks. D. J. McS.

The manufacture of some experimental tank blocks and their behavior in service. W. A. MCINTYRE. *Jour. Soc. Glass Tech.*, **10** [38], 170–76 (1926).—Experimental tank blocks made by using 20 to 50% free silica in batches and their action against soda-lime glass in an experimental tank compared with the action of representative commercial clay blocks and of experimental sillimanite clay blocks in the same tank. The silica con-

taining blocks showed more satisfactory resistance against glass than did the commercial blocks, but showed considerably more corrosion than the sillimanite clay blocks. The best of the latter blocks were those composed of fine sillimanite and fire clay without grog. These blocks showed no corrosion by the glass but warped slightly after firing. D. J. McS.

The thermal expansion of sagger clays. ANON. *Pottery Gaz. and Glass Trade Rev.*, **51** [591], 1384 (1926). Reprinted from *Tech. News Bull.*, 111, 2 (1926). See also *Ceram. Abs.*, **5** [10], 319 (1926). E. J. V.

Refractory materials in glass furnaces. ANON. *Pottery Gaz. and Glass Trade Rev.*, **51** [591], 1406 (1926).—Thin walled porcelain protection tubes used to protect the thermocouple in optical glass furnaces have a life of about 5 days. Petrographic examination of the used tubes shows that the porcelain has broken down from a vitreous aluminium silicate to mullite and free silica. The sodium in the furnace gases presumably reacts with the free silica to form sodium silicate which further reacts with the mullite to form a sodium aluminium silicate which is liquid at the furnace temps., the excess alumina crystallizing out as corundum. It is believed tubes of greater life can be produced by using a higher alumina body and firing it to an initial temp. sufficient to produce practically an entire structure of mullite, thus preventing the formation of free silica at furnace temps. and presumably making it more resistant to the attack of sodium. E. J. V.

The electrical resistance of refractory materials. E. RICHARDS. *Keram. Rund.*, **34**, 475–76 (1926).—R. reviews work done on this subject. The electrical resistance for low voltages may be expressed by the equation $\log P = \frac{A}{T} + B$ where P is the electrical resistance, T is the absolute temp., and A and B are constants for a given material. For high tension work the resistance may be expressed by the equation $\log P = C - DX$, where P is the resistance, X is the voltage, and C and D constants. Quartz glass has a much higher electrical resistance than ordinary glass. A special glass known as "uviol glass" has a higher electric resistance than ordinary glass. Silica and magnesite brick have a higher electrical resistance than chromite or fireclay brick. Diaspore brick also have a high electrical resistance. H. G. S.

Temperature measurement during the load test. H. HIRSCH. *Sprech.*, **50**, 528–30 (1926).—H. measured the temp. of a specimen during a load by sighting on the specimen with an optical pyrometer, (1) obliquely from above, (2) horizontally through a peep hole, and (3) vertically from above. It was found that the temps. observed by the first 2 methods checked fairly closely while those obtained by the 3rd method were considerably lower than those obtained by means of the first 2 methods. H. G. S.

Destruction of coke ovens and the cause. W. MELZER. *Tonind. Ztg.*, **50**, 991–92 (1926).—Coke-oven refractories are corroded by the alkali wash waters from coal which attack the brick forming a glaze on the surface of the same. A brick was divided into 5 layers starting with the glass coating and proceeding to the outside of the brick and the anal. of the different layers were found to be as follows:

Layer No.	SiO_2	Fe	FeO	Fe_2O_3	Al_2O_3	CaO	MgO	Na_2O K_2O	Loss on ignition
1	58.8	7.7	7.7	2.5	24.1	2.5	0.3	4.4	1.0
2	59.7	5.2	3.9	3.1	30.6	1.4	0.2	0.9	0.0
3	60.3	3.6	3.5	1.3	31.2	2.2	0.2	1.2	0.0
4	61.4	4.1	2.8	2.7	30.1	1.3	0.2	1.6	0.0
5	61.2	4.0	2.4	3.0	30.4	1.5	0.2	1.1	0.0

The glassy layer No. 1 contained the highest alkali content which came from the alkaline wash waters. The refractory used in this case with only 31.0% Al_2O_3 is not a high grade fire brick and should be higher in Al_2O_3. Brick for coke ovens should be dense and smooth and the mortar should be high grade. H. G. S.

The refractory industry of Germany compared with that of other countries. H. POHL. *Tonind. Ztg.*, **50**, 1112–15 (1926). H. G. S.

Refractories for the pottery industry. W. EMERY. *Trans. Ceram. Soc.* (Eng.), **25** [2], 111–22 (1926).—One of the essential characteristics of bricks used in the walls and mid-feathers is that they be capable of withstanding the corrosive and solvent action of fusible slags and clinkers. The same is applicable to enamel kiln practice. In continuous firing systems of the chamber type, the refractories used should have an abnormally long life. The blocks or bricks which form the melting hearth of a frit kiln should withstand temps. of the order of 1200–1300° for extended periods, resist changes of temp. which follow as a result of intermittent working, should not contaminate the frit, and most important factor of all, be capable of resisting attack from the semimolten batch. The physical properties of the brick are very important. The adjustment between the matrix and the grog should be such as to insure equal rates of solution. Density is of great importance, porosity being taken as the criterion of this property. The type of pores, however, has a marked effect on the rate of soln. We are more likely to obtain good results from bricks wherein the porosity is due to an infinite number of fine pores, than where a smaller number of large and irregularly distributed cavities are present. A homogeneous structure will lead to a uniform rate of attack compared with marked resistance followed by abnormal erosion. Careful setting has a marked influence on the working life of the hearth. The latter, as far as possible, should form a complete unit, so that the extent of the joints is reduced to a minimum. Larger blocks than the normal "broadbacks" have been used, but the results do not appear to justify their continued use, otherwise they would have become standard. Nine-inch cubes are a standard block and might well be used. R. F. S.

A further note on the storage of silica refractories. W. J. REES. *Trans. Ceram. Soc.* (Eng.), **25** [1], 150–52 (1926).—Highly-fired close-textured bricks are decidedly more resistant to deterioration from exposure to rain, frost, etc., than bricks which have not been so thoroughly fired. None of the brick showed any external evidence of deterioration. The reduction in mechanical strength of the brick which were immersed in water appears to be due to a slight degradation of the bond, as analysis of the water showed that a little lime had gone into solution. Brick which had been wetted by exposure to weather and very rapidly dried in a current of hot air showed a greater loss in mechanical strength than the brick which were slowly dried. Although high-quality silica brick are more resistant to deterioration from exposure to weather, some deterioration will take place on prolonged exposure to weather. It is desirable to protect the brick properly during storage and, especially in the case of blocks, to take precautions to avoid wetting during transit. R. F. S.

Boiler arch problems. W. F. SCHAPHORST. *Power*, **64** [9], 335 (1926).—S. describes how arches should be built so that spalling, checking, and grooving will be reduced to a minimum. He also describes the effect of certain fuels on the refractories. C. J. H.

Mullite brick and research feature refractories meeting. ANON. *Ceram. Ind.*, **6** [6], 608 (1926).—Report of the meeting of the American Refractories Institute at Philadelphia, May 12, 1926. It was shown that the present standard methods of testing refractory brick are not adequate. Suggested modifications are to be recommended to the A. S. T. M. It was brought out by M. L. Freed that the pure mullite brick and the mullite and fireclay brick withstood a pressure of 50 lbs. per sq. in. at 1500°C in a series of tests conducted at the Bur. Stand. Softening point tests showed that mullite

refractories withstood a test above cone 35. The mullite brick showed remarkable resistance to spall. F. P. H.

Superrefractory manufacture. THOMAS S. CURTIS. *Ceram. Ind.*, **7** [1], 47 (1926).—A description of the process by which vitrefrax is manufactured. The grog used is from a high alumina-low-flux clay fired to cone 30. The grog is made in an especially designed calcining machine or converter. The grog is ground so as to produce splintery grains rather than rounded particles. This can be accomplished by a short grind in the pebble mill with a scant charge. This grog is properly sized so as to give a maximum of voids. In determining the bond percentage, the ratio of voids to solid is used, adding 5 % for molding coverage. The bond has the same composition as the grog. The working qualities of the nonplastic high-alumina clay are developed by increasing the fineness of clay substance. The brick is made by the soft-mud hand-mold method and is fired at cone 18 in a 95 ft. tunnel kiln. A tunnel kiln operated at cone 26 is a feature of the plant. F. P. H.

Measurements on the thermal expansion of fused silica. W. SOUDER AND P. HIDNERT. *Chem. News*, **133,** 105–106 (1926).—Abstract of paper published by Bur. Stand. See *Ceram. Abs.*, **5** [9], 273 (1926). E. E. P.

Sintered magnesite. J. BRONN. *Metall u. Erz*, **23,** 91–95 (1926).—The product could be used up to 1900–2000°, density 3.5–3.6, hardness on Mohr scale, 7. Diagrams which show melting points with varying concentrations are given for the binary systems: MgO with SiO_2, with Al_2O_3, with CaO, with $Al_2O_3 \cdot 2SiO_2$, and with $Al_2O_3 \cdot SiO_2$. (*C. A.*)

PATENT

Dolomitic articles and method of making same. H. S. LUKENS. U. S. 1,597,811, Aug. 31, 1926. In the manufacture of composition articles, the process consisting in carbonating MgO to convert it into a binder while accelerating reaction by the presence of $CaCO_3$ in admixture therewith.

Terra Cotta

Machine pressing of terra cotta. ROBERT GALBRAITH. *Jour. Amer. Ceram. Soc.*, **9** [9], 583–86 (1926).—A brief history and a description of the operation of the compressed air pressing machine are given. The manual operations as well as the costs are itemized. The machine requires 15½ men for its efficient operation, while the cost of pressing and finishing one ton of terra cotta is $5.85.

Kiln slabs by specification. R. L. CLARE. *Bull. Amer. Ceram. Soc.*, **5** [9], 358–59 (1926).—The uncertainty as to what constitutes a good slab, why they cannot be bought with some definite idea as to what service will be obtained, etc., are questions raised. Data showing the variation in the life of slabs produced by the same manufacturer are presented. The need for a definite knowledge of the qualitites required in a good slab and for tests which will show these properties is stressed. E. J. V.

Kiln slab specification. F. B. ALLEN. *Bull. Amer. Ceram. Soc.*, **5** [9], 360–61 (1926).—Variations in the life of terra cotta slabs made of one batch under the same phys. conditions throughout appear though every effort at control is made. The need for records as to the life of slabs, information as to the methods of determining this life, etc., is stressed as necessary for a starting point toward the working up of specifications. Coöperation of producers and users will help develop more satisfactory slabs as a result of clearer definition of service and a determination of service conditions. E. J. V.

Use of overglazes for polychrome terra cotta. A. LEE BENNETT. *The Clay-Worker*, **85** [6], 478–79 (1926).—A base white overglaze having the following composition is suggested:

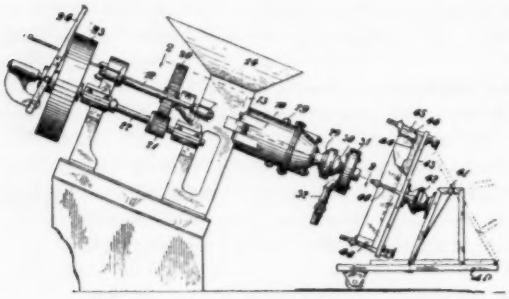
$$\left.\begin{matrix}.621\ ZnO\\ .379\ CaO\end{matrix}\right\}.453\ Al_2O_3\left\{\begin{matrix}1.324\ SiO_2\\ .126\ SnO_2\end{matrix}\right.$$

Various shades of different colors may be obtained by blending the proper stains or coloring oxides with the above glaze. It is made up entirely from either calcined or nonplastic materials. Practically all overglazes are weighed up with about 80% water to the weight of dry overglaze. They are then ground in small pebble mills for 3 hours. The mixed overglaze is sprayed on the terra cotta using a very fine spray gun.

F. P. H.

PATENT

Formation of blocks of terra cotta or the like. R. F. DALTON. U. S. 1,599,216, Sept. 7, 1926. An apparatus for filling molds with stiff plastic material such as terra cotta body, including a mixing apparatus, a screw conveyor receiving material therefrom, a delivery nozzle and connections between conveyor and nozzle for delivering to the nozzle a continuous bar of material under the action of the conveyor, the nozzle being of substantially uniform diameter throughout its length, and having means for delivering air under pressure thereto intermediate of the ends thereof to project the material from the nozzle.



White Wares

Progress report on investigation of sagger clays—some observations as to the significance of their thermal expansions. II. R. F. GELLER AND R. A. HEINDL. *Jour. Amer. Ceram. Soc.*, 9 [9] 555–74 (1926).—This is the 2nd Progress Report based on data obtained in an extensive investigation of sagger clays, conducted for the purpose of determining the properties characterizing clays best suited to this type of service. The report contains a brief description of the apparatus used in the determination of thermal expansion from room temperature to 1000°C together with a correlation of the thermal expansions determined with the physical properties of the clays as given in the 1st Progress Report. For the clays examined the information obtained indicates that: (*a*) there are 2 types of clays as characterized by thermal expansion, between 100°C and 200°C, and resistance to failure when subjected to sudden temperature changes similar to those encountered in service; (*b*) repeated firings tend to develop increased expansion between 100° and 200°C and, consequently, decreased resistance to failure when subjected to sudden temperature changes; and (*c*) that additions of corundum to clay tend to increase the average, but decrease irregular, thermal expansions.

Some successful cone 10 sagger bodies. E. H. FRITZ. *Jour. Amer. Ceram. Soc.*, 9 [9], 606–12 (1926).—The various steps taken in the improvement of a cone 10 sagger body are described, which resulted in the development of several successful bodies giving a life as high as 18 firings. Based on these results, a theory is advanced specifying limits for dry modulus, cone 10 absorption, and total shrinkage of the body, which if met regardless of clays used, will produce results such as were here obtained. Verification of this theory by others is requested.

A simple "sealed-in mercury electrode" apparatus for testing the breakdown voltage of heavy insulating materials. LOUIS NAVIAS. *Jour. Amer. Ceram. Soc.*, 9 [9], 598–

605 (1926).—A method has been developed whereby thick plates of insulating materials (of small area) may be electrically punctured under oil. The specimen is cemented between 2 hollow electrode holders by means of red sealing wax. One electrode holder, the elbow, may be made of ordinary cast-iron piping or glass. Mercury poured into both tubes gives the necessary contact. It is possible by these means to puncture a porcelain cylinder of diameter 1¼ in. and 1½ in. thick at 142 kv., and with a porcelain cylinder 2 in. in diameter and 2 in. thick to reach 176 kv. without arcing. The "sealed-in mercury electrode" method has been compared with 2 other methods employing spheres and disks as electrodes, by puncturing cast polished plate glass specimens. The new method gives consistent results, the values being on the average 15% higher than values obtained by the other 2 methods.

New spreader and rotary lawn successful in whiteware plant. ANON. *Ceram. Ind.*, **7** [2], 130 (1926).—Advantage of spreader over battering out is explained. The new lawn is said to be easier on the fabric than older types. F. P. H.

Sanitary plant uses refrigerated glaze. ANON. *Ceram. Ind.*, **7** [3], 244–53 (1926).—A description of methods and equipment used at the plant of the Eljer Co. The glaze material is ground to an impalpable fineness by flint pebbles in 3 ball mills. The material is then screened and passed over a set of electro magnets to remove any traces of iron. To produce the proper consistency and ease of handling the glaze is now kept cool in a small Frigidaire refrigerator until ready to use. It has been found that if the temp. goes much above 45°F the glaze starts to coagulate, and if painted on when in this condition it invariably pulls off the first coat. When one considers the fact that 5 coats of glaze are painted on some pieces one can judge how much care must be used in each step at this point. It has been found that 1% of borax in the glaze proved a good fastener and prevented the glaze from rubbing off. It is claimed that this Company operates the largest tunnel kiln. F. P. H.

Specifications and physical tests for table chinaware: their meaning to the producer and user. A. N. FINN. *The Ceramist*, **8** [5], 330–37 (1926).—The purchaser can be assured that the material he buys is of satisfactory quality and the manufacturer can know that he is producing ware of his own standard of quality only if frequent, satisfactory tests are used. F. gives the properties a specification should have in order to give the desired service. The work of the Chinaware Committee of the Federal Specifications Board is outlined. F. discusses the test methods in use, the extent of the specifications, the proposed changes and the value of specifications. The developments of Pyrex glass and spark plug porcelain are given as examples of the importance of tests. F. then discusses the question of foreign ware and the importance of finding a good hardness test. A. E. R. W.

Formulas for slip calculations. S. R. HIND. *Trans. Ceram. Soc.* (Eng.), **25** [2], 108–10 (1926).—In cases where any large number of varied calculations have to be carried out in connection with slips (suspensions) of clays, various ground materials and their mixtures, it has been found of great service to have a collection of formulas from which the desired quantity may be directly calculated. All the formulas given are based on the simple principle underlying Brongniart's, viz., that the suspended material displaces its own volume of water. R. F. S.

The German electrical porcelain industry. ANON. *Pottery Gaz. and Glass Trade Rev.*, **51** [591], 1386 (1926).—The electrical porcelain industry shows an increased production of 50% of high voltage, and 85% of low voltage insulators in 1925 over 1924. E. J. V.

Abrasive hardness of ceramic glazes. ANON. *Pottery Gaz. and Glass Trade Rev.*, **51** [591], 1384 (1926). Reprinted from *Tech. News Bull.*, 111, 1–2 (1926). See also *Ceram. Abs.*, **5** [10], (1926). E. J. V.

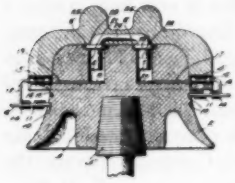
The china clay industry. ANON. *Pottery Gaz. and Glass Trade Rev.*, **51** [591], 1420–22 (1926).—A report of very gratifying conditions in the English china clay industry. E. J. V.

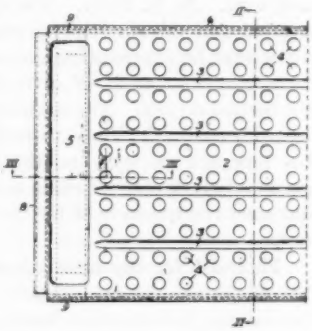
The effect of potters' flint on whiteware bodies. E. E. PRESSLER AND W. L. SHEARER. *Pottery Gaz. and Glass Trade Rev.*, **51** [591], 1406 (1926). Abstract of Bur. Stand. *Tech. Paper* No. 310).—The firing behavior of the bodies is affected more by the fineness of the flint and the presence of impurities than by the type of flint. Typical heat absorption and thermal expansion effects were found at the quartz inversion temp. and were roughly proportional to the percentage of free quartz in the samples. E. J. V.

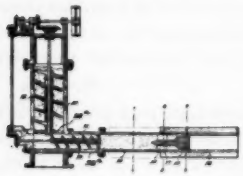
Bronze tablet memorializes James Bennett, pioneer East Liverpool potter. ANON. *Pottery, Glass and Brass Salesman*, **34** [6], 25 (1926).—An account of the pottery built by James Bennett, in whose memory a tablet has been placed in the library at East Liverpool. E. J. V.

PATENTS

Testing insulator. H. E. MARTZ. U. S. 1,597,610, Aug. 24, 1926. An insulator for the line wires of a telegraph system, including a body of insulating material having its upper corner rounded and its sides flared outwardly from the corner and having spaced peripheral grooves, line wires wound around the body in the grooves and having their ends wound around the wires proper, the body having spaced sockets entering from the top thereof and having rounded depressions in the top surrounding the sockets, a bridge wire wound around and secured to each of the line wires, and directed toward the body, copper lugs secured to the ends of the bridge wires, a socket for each lug, a conductor plate connected to each lug, entering the body and having a head portion received in the respective sockets of body, a cover received over the top of the body and having depressions that receive therein the joint between the line wires and the conductor plates, a substantially U-shaped circuit breaker having its central portion embedded in the cover and having its parallel arms received in the respective sockets, and an electric conductor in each socket between the arms of the circuit breaker and the heads of the conductors, and the arms of the circuit breaker having annular shoulders, which rest on the inner walls of the depressions that surround the sockets and hold the cover from frictional engagement with the body.



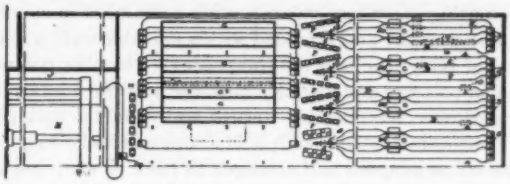




Pallet for tiles. R. V. PROCTOR AND H. M. SCHAAB. U. S. 1,597,820, Aug. 31, 1926. As an article of manufacture a pallet comprising a metallic supporting body having at least one opening therethrough for the circulation of air, means for reinforcing body throughout the central and edge portions thereof to prevent bending, and supporting legs projecting downwardly from body.

Process of and apparatus for making articles of ceramic material. C. G. KOPPITZ. U. S. 1,598,201, Aug. 31, 1926. A process of molding material, which consists in forcing

a plastic material against the wall of a mold thereby causing the mold to move in the direction of the axis thereof.



Method of manufacturing pottery ware. EDWARD S. LEA. U. S. 1,600,286, Sept. 21, 1926. The method of manufacturing pottery ware from slip which comprises assembling the elements of absorbent molds on trucks and effecting the sequential operations of pouring the slip in the molds, preliminarily drying the castings, separating the mold elements, partially drying the castings, and dumping the latter from the molds, while the mold elements are retained in proper relative arrangements on the trucks.

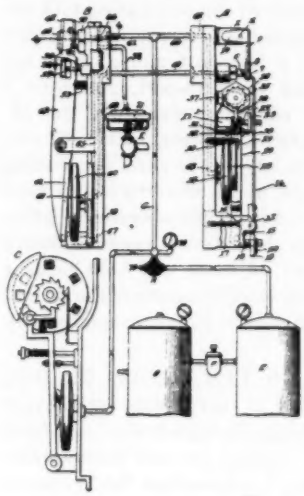
Equipment and Apparatus

Grinding glazes and enamels in pebble mills. R. L. CAWOOD. *Ceram. Ind.*, **7**[3], 254–55 (1926).—Practical suggestions about the manipulation of pebble mills are given. It is claimed that the largest sized mill that can possibly be used for a given purpose is always the more economical to buy and the cheapest to operate. F. P. H.

Pore diameter in filtration and percolation. A. MÜHLHAUS. *Koll. Z.*, **39**, 37–40 (1926); *Chem. and Ind.*, **45B**, 615 (1926).—A discussion of various filtering and sieving surfaces, special attention being devoted to wire and silk gages and to the discrepancies which occur between actual pore diameter and that calculated from the number of filaments as stated by the manufacturers. H. H. S.

PATENTS

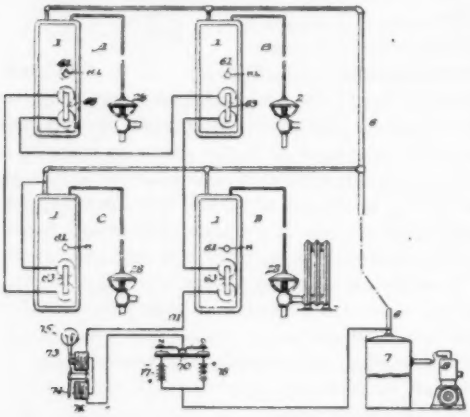
Method and means for control of temperature. C. L. FORTIER. U. S. 1,597,348, Aug. 24, 1926. In a temperature control system of the compressed air type, a pipe or conduit for the compressed air; a 3-way valve in conduit for alternately opening and closing said conduit to permit or prevent the passage of air to the actuating motor of a heat-control valve; a pneumatic motor in communication with air conduit for actuating 3-way valve, provided with 2 vents, the opening of either of which will vent the motor and permit a return movement of its movable wall; a valve for sealing and unsealing one of the vents, carried by a member in sealing and unsealing directions in response to rise and fall of temp.; a second valve for sealing and unsealing the other vents; pawl and ratchet mechanism for effecting the alternate sealing and unsealing of second vent by successive step-by-step advances of the ratchet; a 2nd pneumatic motor in communication with the air conduit, serving to actuate ratchet mechanism in response to alternate decrease and increase or restoration of pressure in air conduit; and means for temporarily varying the air pressure in conduit and restoring it to normal.



Control system for temperature, humidity, and the like. C. L. FORTIER. U. S. 1,597,349, Aug. 24, 1926. In a temp. control system of the compressed air type, the combination of a source of air under pressure; a self-opening heat control valve provided with a pneumatic motor for closing it; a secondary valve serving alternately to open communication between the source of air under pressure and the

pneumatic motor, and to close such communication and vent the motor; a relay for actuating secondary valve, having a chamber in communication with the source of air under pressure and provided with a movable wall; a selector for controlling the functioning of relay, the selector comprising a chamber communicating with the source of air under pressure and having a movable wall and a leak-port for venting the relay chamber; a pad or valve movable toward and from the leak-port to seal and unseal the same; 2 thermostatic strips, each held at one end and overlying at its free end the pad or valve, the strips adapted and arranged to bend or warp toward, and to press pad into sealing relation with the leak-port on rise of temp. in the surrounding medium; and means for putting pad under control of either one of strips at will.

Temperature-control apparatus. C. L. FORTIER. U. S. 1,597,350, Aug. 24, 1926. In a control system of the compressed-air type, the combination of a main air supply pipe; means for connecting pipe at will with either of 2 sources of air of relatively different degrees of compression, and disconnecting it from the other sources; a selector comprising 2 elements both responsive to atmospheric changes of like character, and each adjustable independently of the other to cause the two to function at different p...nts in the scale of such atmospheric changes; a stop element located in the plane of movement of one of the elements but adjustable to and from a position in which it will arrest such movement; an air chamber in communication with the air pipe and having a movable wall or portion capable of action in response to inflation and deflation of chamber to directly throw the stop element into position for arresting the responsive element with which it is associated, or to permit stop element to withdraw from such position.

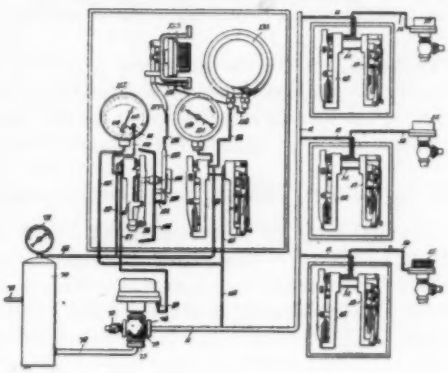


Control system for temperature humidity and the like. C. L. FORTIER. U. S. 1,597,351, Aug. 24, 1926. In a control system of the character described, the combination of a pressure-fluid conduit communicating with a plurality of rooms; a plurality of control instruments, one for each room in which control is to be effected, each such instrument communicating with the pressure-fluid system and provided with a leak-port and a valve for closing the leak-port, and with 2 like elements responsive to atmospheric changes, both such elements adapted to effect the seating and unseating of valve in response to atmospheric changes; means whereby one element of each instrument may at will be held out of or permitted to go into operative relation with the leak-port valve; an electromagnet associated with the last-mentioned responsive element of each instrument and serving, when energized, to move and hold element out of valve-closing action; an electric circuit including the electromagnets of the several instruments; and means for momentarily completing the electric circuit to temporarily energize the magnets.

Temperature-control apparatus. C. L. FORTIER. U. S. 1,597,352, Aug. 24, 1926. A pneumatic temp. control system, comprising a plurality of thermostats each having a leak-port and a thermostatic strip movable through temp. changes toward and from sealing position against the leak-port nipple; a saddle or support for each thermostatic strip, tending to carry strip toward the leak-port nipple; 2 independent fluid pressure

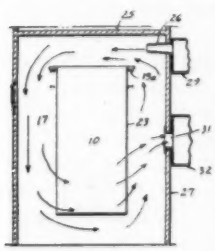
motors associated with each saddle and thermostatic strip and each provided with a lever having a stud or projection to bear against and support the saddle at one or another predetermined adjustment as one or the other lever is moved to saddle-supporting position; springs acting upon levers and tending normally to collapse the motors with which they are respectively associated; adjustable stops to limit and determine the movement of the levers and the consequent adjustment of the saddle; and means for deflating the motor controlling one lever and inflating the motor controlling the other lever, both from a central point; whereby the thermostatic strip is placed under control of either saddle support at will and is caused to maintain a relatively higher or a relatively lower temp. as desired.

Setting device for temperature-control instruments. ARTHUR J. OTTO AND C. A. OTTO. U. S. 1,597,353, Aug. 24, 1926. The combination with a temp. control system including a pressure fluid supply line and a plurality of pressure fluid controlling thermostats, each connected with said line and each including means for changing its adjustment operable by a wave of abnormal pressure in the supply line; of valve means operable to initiate a change of pressure in line; and automatic means responsive to the resulting change of pressure and serving to restore normal pressure in line.

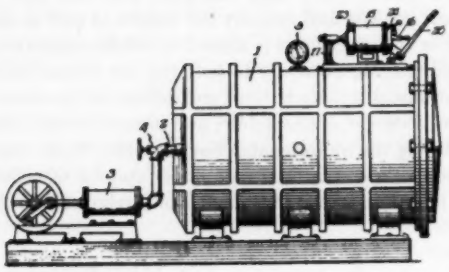


Selective-control thermostat system. A. J. OTTO. U. S. 1,597,354, Aug. 24, 1926. The combination of a pressure fluid thermostat having a pressure fluid supply line arranged to operate at a definite normal pressure; shiftable means for adjusting thermostat to vary the temp. maintained thereby; a motor subject to supply line pressure and so related to adjusting means that a surge of increased and decreased pressure in the pressure line act through the motor to shift adjusting means in respectively opposite directions; means for maintaining normal pressure in the supply line; and means for producing selectively and at will pressure surges above and below said normal pressure.

Thermostat. J. C. GIBSON. U. S. 1,597,356, Aug. 24, 1926. A thermostat comprising a base plate, a lever arm pivoted at one end to plate to have a limited swinging movement, a stop to limit the swing of arm, a pair of electrodes, one carried on lever arm and the other mounted on plate in position to engage with the electrode on lever arm, an automatically actuated member mounted on plate and arranged substantially in longitudinal alinement with lever arm and connected at one end to plate, and a helical spring connecting the other end of member with lever arm at a point remote from its pivotal connection to plate, the spring being disposed in tension nearly in alinement with the end of the member, the spring having a stiffening rod embraced therein but unconnected to spring, member or lever arm and stop being arranged to frictionally oppose the swing of spring and rod.



Method of and apparatus for uniformly drying or processing materials. A. E. STACEY. U. S. 1,599,797, Sept. 14, 1926. The method of treating materials with air and other gaseous fluids which includes



subjecting the mat. in succession to the action of currents of fluid and so directing the fluid currents which differ in velocity that the currents of the highest velocity are caused to impinge on different zones of the material at different times.

Means for treating ceramic mixtures. HARRY SPURRIER. U. S. 1,600,493, Sept. 21, 1926. Means for treating materials, comprising a vessel, means for evacuating the air from vessel, and an air-controlling means for governing communication between the interior of vessel and the outside atmosphere, air-controlling means comprising a valve, a spring for biasing valve to open position, means for moving valve to closed position in opposition to spring, and detent means for releasably holding valve in closed position.

Kilns, Furnaces, Fuels, and Combustion

Tunnel kilns for firing fire bricks. S. R. HIND. *Trans. Ceram. Soc.* (Eng.), **25** [2], 154–64 (1926).—Restricting the problem to that of firing fire brick, it may be definitely stated that continuous kilns have proved themselves superior to intermittent kilns. The most economical type of kiln will fire fire brick at cone 10 on less than 10% of the weight of the product. The tunnel kiln has the incontestible theoretical advantage that its structure is maintained constantly at a fixed range of temps. and, thus, is not subject to the loss of heat, and therefore fuel, that result from the periodic heating up and cooling of walls which of necessity accompany the firing in the stationary-goods type of kiln. The quality of the product depends not only on uniform firing to the correct finishing temp., but also upon satisfactory treatment in every stage from commencement of water-smoking to finish of cooling. There are certain conditions in which a tunnel kiln is definitely less convenient than a chamber kiln or similar type. Such conditions arise in an old-established works where the site available for a new kiln is cramped. The most suitable type of tunnel kiln for fire brick is the open-fire type, in which the products of combustion pass directly through the goods. The most desirable features of design which a tunnel kiln should possess, particularly for the firing of fire brick are: (1) A long firing zone to insure adequate soaking of the goods. This is largely a question of the thickness of the individual pieces. Table-ware and stoneware can be fired successfully with only small provision for soaking, but the thicker the goods the longer is the time required for their proper heat-treatment. (2) An open-fired kiln (this largely from the point of view of securing low fuel consumption and robust construction in the high-fire zone). Fuel economy also demands that the cross-section of the kiln shall be as large as possible and of as short a perimeter as possible. (3) A type of construction which has the utmost flexibility in the matter of arranging for uniform heat-distribution throughout the goods and for proper variation of the rate of heating in certain critical preliminary stages of firing. (4) A structure which, while being extremely robust, allows of the best possible use of the heat which is permitted to pass through the walls and crown by conduction. The ideal is to use insulating material (diatomaceous earth in some form is almost invariably used) to the best advantage and then to have the bulk of the cooling and high-fire zones surrounded by air-spaces. Air drawn through these spaces will then recover practically the whole of the heat otherwise lost. (5) Radiation from solid surfaces much hotter than the goods being fired should be avoided. It is practically impossible to get uniform firing of a setting where the crown or a combustion-pocket present strongly overheated surfaces. The outer surfaces of the setting

will more or less completely shield the great bulk inside from such radiation. The subsequent slow conduction of this heat through the setting cannot, in a reasonable time, correct the great differences of temp. set up. (6) A correct balance between the resistance of the full tunnel to the passage of the hot air (or products of combustion) and the hydrostatic pressure of the furnace gases entering the tunnel. R. F. S.

Pulverized coal as a fuel; its merits and hazards. L. D. TRACY. *Nat. Glass Budget*, **42** [18], 20 (1926).—A summary of Bureau of Mines, *Bulletin*, 242, covering the following points: use of pulverized coal in industrial plants; phys. characteristics; measurement of explosiveness; and a summary of regulations looking to a safer operation of pulverized-fuel plants. E. J. V.

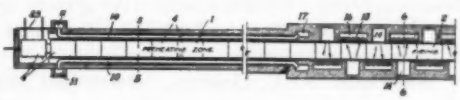
New type tunnel decorating kiln a success. ANON. *Ceram. Ind.*, **7** [1], 45–46 (1926). —This kiln located at the Limoges China Co., Sebring, Ohio, plant is 145 ft. in length, 3 ft. 9 in. wide inside, with a maximum height to the spring of the crown of 6 ft. 2 in. The hot zone of the kiln, kept at 1350°F, is located 48 ft. from the entrance of the kiln and this zone is 46 ft. in length. The kiln has downdraft floating double wall combustion chambers and the advantages of a long soaking zone which insures uniform firing and practically no chance of overheating by direct radiation. F. P. H.

Institution of fuel technology. ANON. *Chem. and Ind.*, **45**, 560 (1926).—This Inst. has been founded in London for the purpose of securing the support and coöperation of all interested in fuel and fuel problems. Sir Alfred Mond is the first president. H. H. S.

Surface combustion and its influence on the future economics of heat and power. T. G. TULLOCH. *Chem. and Ind.*, **45T**, 280–87 (1926). H. H. S.

PATENT

Method and apparatus for firing clay ware. W. D. RICHARDSON. U. S. 1,599,589, Sept. 14, 1926. The method of firing clay ware in tunnel kilns which comprises subjecting the ware to a series of hot gases which move in opposite directions transversely of the tunnel.



Geology

The Lough Neagh clays. W. B. WRIGHT. *Trans. Ceram. Soc.* (Eng.), **25** [2], 171–83 (1926).—This gives a geological report of the Lough Neagh clays found on the shore of Washing Bay, County Tyrone, in northern Ireland. R. F. S.

Clay resources of South Carolina. M. E. BARKER. *Ceramist*, **8** [4], 249–65 (1926).—Clay and clay products form the most valuable mineral industry in S. Carolina. After a brief reference to the history of clay exploitation, B. describes the geological and topographical provinces in the State and their principal minerals. The principal clay areas are then described as well as the nature of the deposits. B. classifies the S. Carolina clays both according to origin and to use. Tables of the physical and chemical properties of the clays are given and their significance discussed. All clays in the State are mined by the open pit method. Only one mine produces a washed clay. The marketing methods used are outlined. A table gives the values of the principal clays and clay products of the State during the past 2 decades. Its standing among the other states is discussed. A similar table shows the values of brick and tile production. A.E.R.W.

More about the feldspar industry of western North Carolina. ANON. *Ceramist*, **8** [4], 266–69 (1926)).—Letters protesting that paper previously published (*Ceramist*, **8**, 176–79 (1926) contained misleading statements. For abstract see *Ceram. Abs.*, **5** [10], 326 (1926). A. E. R. W.

A whiteware plant in Brazil. F. KINDEL. *Keram. Rund.*, **34,** 508–509 (1926).—The first white ware plant in German South Brazil is described. A kaolin and pegmatite having the following compositions were discovered:

	Kaolin	Pegmatite
Al_2O_3	38.85	17.89
SiO_2	44.58	68.50
MgO	0.07	0.10
CaO	0.13	0.10
Fe_2O_3	0.48	0.26
K_2O	0.32	0.98
Na_2O	0.18	11.10
Loss on ignition	15.53	1.10

A light firing clay and a pure white marble were also found. Practically all of the grinding and pugging equipment are made of hard wood and gas pipe. After many difficulties a high grade of white ware is now being made. H. G. S.

Quartz sand and rock quartz are two different mineralogical forms. T. SCHAUER. *Sprech.*, **59,** 473–75 (1926).—It has been known for some time that Norse quartz, which is a rock quartz, produces more translucent porcelain than quartz sands obtained in Germany. It is claimed that the rock quartz is largely α quartz while the quartz sands are largely β quartz. H. G. S.

Brickearth and clay. C. E. N. BROMEHEAD. Great Britain Geol. Surv. Mem., 1926.—The Geology of North London. Brick earth and clay. Pp. 57–58. O. P. R. O.

Underclays and coal formation. PERCY KENDALL AND A. GILLIGAN. *Colliery Guar.*, **132,** 346 (1926).—Underclays and the "growth in place" theory of coal formation. The root bed or seat of true coal might be clay, sandstone (yielding ganister, which was full of roots), or of limestone. O. P. R. O.

Fluorspar. C. C. MORTON. *Queensland Min. Jour.*, **27,** 202 (1926).—It is assumed that a large tonnage of high grade fluorspar could be quickly and cheaply extracted in the Mungana District should economic considerations admit its exploitation. O. P. R. O.

Bauxite reserves in Jugoslavia. ANON. *Queensland Min. Jour.*, **27,** 214 (1926).—The reserve of bauxite in Jugoslavia constitutes one of the world's most important sources of supply and reserves for the future. Analyses show high alumina content, with low silica content. O. P. R. O.

Talc-soapstone-steatite. ANON. *The Clay-Worker*, **85** [6], 468–69 (1926).—These terms are defined. Their occurrence and uses are given. F. P. H.

Chemistry and Phyics

Non-metallic acid-resisting materials. LEONARD CARPENTER. *Chem. Age*, **15,** 199–200 (1926).—Silica ranks high among acid-resisting materials because of chem. inertness, non-absorbent character, and low coefficient of expansion. Combinations of silica with certain bases show less resistance to acids, but reduce brittleness and cost. Acid-proof bricks and stoneware are much used in chemical industries. Minimum basic content and well vitrified body are essential. Chemical stoneware is a similar product having a wide range of vitrification. Acid-resisting cements consist generally of silica sand or asbestos bonded with sodium silicate, or other bonding material. E. E. P.

Antagonistic action of ions in the coagulation of colloids. K. C. SEN. *Chem. News*, **133,** 131–32 (1926).—Digest of literature on subject, and discussion of theoretical considerations. E. E. P.

Standard methods for quantitative silicate analysis. G. A. KALL. *Sprech.*, **59**, 510–11 (1926).—K. describes the determination of SiO_2, BaO, Fe_2O_3, TiO_2; the separation of Al, Fe, Zn, Co, and Mn, and the determination of Zn, Co, Mn, Ca, Mg, and As. H. G. S.

Some changes taking place in the low-temperature firing of Stourbridge fire clay. II. C. E. MOORE. *Trans. Ceram. Soc.* (Eng.), **25** [2], 127–47 (1926).—The curve obtained on plotting coefficients of expansion against firing temp. shows a decrease in coefficient on attaining the dehydration temp. range; an increase at 690° followed by a reversal; above this range, ending at about 800°, a continuous increase along a straight line curve showing, however, 2 steps; a decrease at 905° and a decrease at 1000° (about). Another prediction following from these theoretical considerations is that of 2 samples of clay similarly fired but cooled at different rates; that which has been cooled more quickly should show enhanced chemical activity. This has been investigated by firing clay to various temps. and "soaking" at these temps. to complete all changes as far as possible and ensure that observed effects are due solely to variations in the cooling process. Results are given showing thermal treatment, strength of acid used, and temp. and time of attack. With rapid heating 2 distinct stages are observed in the dehydration process. With very slow heating (including "soaking" at various temps.) the water evolved on rapid heating as a second stage is given off progressively after the first loss is complete, but has so far not been identified as a portion of the first process deferred. On the contrary, it appears to be of a distinctly different character. A number of cylinders of clay 1 in. high and 1 in. in diameter, were fired to various temps. and tested for "elastic hardness" by the scleroscope method. This method depends on observations of the height of rebound of a hardened steel hammer dropped from a standard height on to the surface of the specimen. Some 30 determinations were made on each specimen on a polished face and the mean of the results taken. Actual variations over the surface did not exceed 2 hardness numbers and the majority were of identical value. The curve shows the 700, 920, and 1030 changes distinctly and indicates the similarity in nature of the 2 latter. Two sets of results are given graphically and also a proposed explanation discussing the rehydration of fired clay. From contraction experiments, it was concluded that the presence of the 3 "critical ranges" was established, allowing that such factors as rate of heating largely influence the results. R. F. S.

American soils with reference to relationship between chemical composition and physical properties. H. H. BENNETT. *Soil Sci.*, **21**, 349–76 (1926); *Chem. and Ind.*, **45B**, 640 (1926).—Clay soils of tropical America and of the southeastern U. S. may be distinguished into 2 types: friable and plastic. The friable has low SiO_2 and high R_2O_3, the molecular ratio $SiO_2 : R_2O_3$ being less than 2. In the plastic type the ratio is greater than 2. H. H. S.

Sericite as a source of potassium. E. BLANCK AND F. ALTEN. *Landw. Vers. Stat.*, **104**, 237–43 (1926); *Chem. and Ind.*, **45B**, 641 (1926).—The potash-mica sericite failed to give encouraging results when used as a source of potash in vegetation experiments. H. H. S.

Determination of sodium. L. BARTHE AND E. DUFILHO. *Compt. rend.*, **182**, 1470–73 (1926); *Chem. and Ind.*, **45B**, 644 (1926).—Na may be determined by precipitation as triple acetate of U, Mg, and Na. If organic matter is present it must be destroyed by HNO_3 and HSO_4, and phosphates should be precipitated by a U-salt in hot solution. H. H. S.

Relationship of climate and soils in Europe. A. MEYER. *Chem. Erde*, **2**, 209–347 (1926); *Chem. and Ind.*, **45B**, 684 (1926).—An exhaustive account of investigations on the influence of climatic factors, temp. abundance or shortage of water, on the origin and character of European soils. A bibliography of 160 titles is included. H. H. S.

Transformation of sillimanite. F. RAAZ. *Mineralog. petrog. Mitt.*, **38**, 583–90 (1925). —A crystal showed no change at 1100–1200° but between 1600° and 1700° it changed in density from 3.247 to 2.950. It was then found to consist of mullite and a glass. Determinations of electric conductivity of sillimanite up to 1350° fall on a continous curve. (*C. A.*)

Quantitative mineralogical analysis of rock-dusting materials. A. H. EMERY AND R. DECHICCHIS. Carnegie Inst. Technology, *Mining and Metal. Invest. Bull.*, **21**, 1–41 (1925).—Methods of quantitative mineralogical analysis are discussed under the following headings: (1) Chemical methods. (2) Density methods. (3) Magnetic separation. (4) Electrostatic methods. (5) Mensuration methods. (*a*) Areal methods. (*b*) Linear methods. The mineralogy and quantitative petrography are discussed for the following rock-dusting materials: limestones, gypsum rock, and clays and shales. (*C. A.*)

Some data in connection with the determination of the molecular weight of organic compounds by the method of Rast. V. S. SADIKOV AND A. MICHAILOV. *Jour. Russ. Phys. Chem. Soc.*, **56**, 109–14 (1926); *Chem. Zentr.*, **1926**, I, 815.—Normal molecular weights in camphor (cryoscopic) were found for 17 different classes of organic compounds. Pinene, bromocamphor, and arabinose gave an abnormally small depression of the freezing point, whereas borneol raised the melting point of the camphor. (*C. A.*)

BOOK

Colloid and capillary chemistry. H. FREUNDLICH. Trans. from 3rd Ger. ed. by H. S. HATFIELD. London: Methuen and Co., 1926. Price 50*s* net. H. H. S.

General

Pithy report of the Bureau of Standard's work. ANON. *Ceram. Ind.*, **7** [3], 256–58 (1926).—An abstract of the report of the Bureau of Stand. work on ceramics for 1925–26. The following problems were studied: (1) Viscosity of glasses. The viscosity of 6 glasses at several temps. and the composition of the glasses are given. (2) Tank block erosion. Effect of composition and structure on length of service. (3) Feldspars. Effect of the feldspars on the porosity and volume shrinkage of whiteware bodies fired at different temps. The use of the microscope in analyzing feldspars. (4) Hardness of glazes. Effect of firing temp. and composition on hardness of glazes. (5) Changes recommended for table glassware specifications. (6) Composition and physical properties of special glasses. (7) Stones in glass. By using the petrographic microscope the compositions of the crystalline materials produced in soda-lime glasses were determined and were found to be wollastonite and Na_2O 3CaO 6SiO in window and plate glasses and cristobalite in bottle glass. (8) Effects of typical enamels on colors obtained with stains. (9) Cast iron for enameling. (10) Physico-chemical factors affecting properties of enamel suspensions. (11) Investigation of relative softening points of English, French, German, and American-made pyrometric cones. (12) Linear thermal expansion of sagger clays and other refractory materials. F. P. H.

What is the limit in reducing excess air? E. G. BAILEY. *Power*, **64** [2], 65 (1926).—B. describes the effect of varying excess air in boiler furnace operation. A reduction in excess air raises furnace temp. which means higher upkeep of stoker parts, burners, and refractories. C. J. H.

Speed reducers, where they should be used and why. ANON. *Ceram. Ind.*, **6**[6], 572–74 (1926).—Advantages of the enclosed speed reducer unit over drives by chains, belts, pulleys, open gearing are given. Six general types of speed reducers are described F. P. H.

Novel use of steam in filter pressing. ANON. *Ceram. Ind.*, **7**[1], 42–44 (1926).—A description of methods and equipment used at the plant of the Electrical Refractories

Co. The filter pressing at the plant is done at 60 lbs. in about 1½hrs. It was found that this schedule prevented the segregation of neither flint nor feldspar as is sometimes noted when the pressure is too high. After the filter press is filled, the soft slip which is often found around the center of the cake is blown out by steam or air. In this way the material which clogs the sacks, causes a sloppy cake and also a certain amount of deterioration around the delivery opening is disposed of. A new method of producing tubes of accurate dimension and a novel method for drying these tubes are described. F. P. H.

Smoke elimination. ANON. *The Clay-Worker*, **85** [6], 463–65 (1926).—Description of a process devised by W. C. Mitchel by which the smoke menace is eliminated. The process is termed the ceramic combustionizer. An application of the steam jet principle in a very effective way, the steam jet being introduced over the top of the fireplace on the boilers and updraft kilns with some new and improved elements. He uses a double cone for his jet, the steam passing between the 2 cones before entering the usual steam jet. By this process the steam is superheated while the nozzle of the cone is cooled, adding to its life and efficiency. There is an automatic adjustable time device which admits the steam into the jet at the beginning of the firing process and thus a decided economy over the continuous use of the jet results. F. P. H.

New Jersey clay workers hold summer convention. ANON. *Ceramist*, **8** [4], 227–48 (1926).—An account of the meeting including a report of a long and interesting discussion on "Specifications for Kiln Slabs," and papers on "Art in Industry," "The Use of Ceramic Products in the Construction of the Holland Tunnel" and "Specifications and Physical Tests of Tableware." A. E. R. W.

Bureau of Standards investigations of pottery, heavy clay products, glass, and enamels. ANON. *The Ceramist*, **8** [5], 285–329 (1926).—A summary of the activities and accomplishments of the Bur. Stand. in the field of ceramics since August, 1925, under the following heads: *Pottery and fine ceramics.* (1) Investigation of feldspars and their effect on pottery bodies. (2) The quantitative microscopic analysis of commercial feldspars. (3) The resistance of ceramic glazes to abrasion. (4) The study of potter's flint and its effect in pottery bodies. (5) Physical properties of vitreous china bodies. *Glass.* (1) Specifications of table glass-ware. (2) A study of the composition and physical properties of special glasses. (3) Relations between chemical composition and physical properties. (4) A non-actinic, cobalt-blue glass. (5) Paper on the annealing of glass. (6) Tank control and devitrification. (7) The measurement of the viscosity of glass. *Refractories.* (1) Comparative tests of some American and German fireclay brick. (2) The manufacture of fireclay brick. (3) A new type porcelain protection tube. (4) Microscopic examination of boiler furnace refractories. (5) Problems relating to sagger clays. (6) Microscopic examination of sagger bodies. (7) Study of tank block. *Enamels for metals.* (1) The effect of typical enamels on colors obtained with various stains. (2) Cast iron for enameling purposes. (3) Investigation of the field of ground coat and white cover enamels for sheet iron and steel. (4) Physico-chemical factors affecting the properties of enamel suspensions. *Heavy clay products.* (1) Physical properties of clay bodies as affected by drying treatment. (2) Problems relating to the design of hollow tile and brick extrusion machines. (3) Hollow tile and concrete floor slabs. (4) Compressive and transverse strength of hollow tile walls. *Miscellaneous.* (1) Molding, annealing, and inspection of optical glass. (2) Routine production of refractories. (3) Pyrometric cones. (4) Use of cyanite. (5) Exhibit of ceramic products. (6) List of fellowships. A. E. R. W.

New course in ceramic engineering. ANON. *Amer. Glass Rev.*, **45** [42], 36 (1926); *Nat. Glass Budget*, **42** [12], 19 (1926); *Glass Industry*, **7** [8], 203 (1926); *Bull. Amer. Ceram. Soc.*, **5** [8], 349 (1926). See also *Ceram. Abs.*, **5** [9], 288 (1926). E. J. V.

Proposal for an American Ceramic Institute discussed. Ross C. Purdy. *Glass Ind.*, **7** [9], 222–23 (1926).—A discussion in considerable detail proposing the establishment of an American Ceramic Institute. Make-up, financing, and value of such an Institute are among the details discussed. E. J. V.

Influence of chemistry on ceramics. Ross C. Purdy. *Ind. Eng. Chem.*, **18** [9], 952–53 (1926).—Today an accurate knowledge of mineral compositions and properties and the resultant products of heating mixtures of silicate minerals to a degree of fusion is quite general. Present day ceramists usually have a greater knowledge of the chemistry of their materials and material-compounding than did the best informed ceramist of 50 years ago. This generally possessed chemical knowledge makes possible the production on a large scale of ceramic wares of definite properties within exacting limits of variation. E. J. V.

Technical classes in pottery and glass. Anon. *Pottery Gaz. and Glass Trade Rev.*, **51** [591], 1389–90 (1926).—A compilation of a list of technical schools, their curricula, teaching staffs, and other information regarding them. E. J. V.

Summer meeting of the American Ceramic Society. Anon. *Pottery, Glass, and Brass Salesman*, **34** [4], 25 (1926).—An outline of the program for the meeting at Philadelphia, Aug. 30–Sept. 2, inclusive. E. J. V.

Progress and problems of firing practice and boiler construction. A. Loschge. *Archiv. Wärmewirtschaft*, **7** [8], 218–26 (1926).—Descriptions and illustrations of movable-grate installations, also construction features of air preheaters with water-cooled walls. Discussion of powdered coal firing, and combustion space requirements. Theoretrical considerations involved in boiler construction. E. E. P.

BOOK

Griffiths, Ezer: **Methods of Measuring Temperature.** 2nd ed. London: Charles Griffin & Co.; Philadephia: J. B. Lippincott Co. 203 pp. 10*s* 6*d*. Reviewed in *Mining Met.*, **7**, 274 (1926). (*C. A.*)

BOOK REVIEWS

Enameling on Metal—A Practical Manual on Enameling and Painting on Enamel as Applied Particularly to Gold and Silver Ware and Art Metal Work. By L. E. Millenet. Translated from the French by H. de Koningh. 112 pages. Crosby Lockwood & Son, London; D. Van Nostrand Co., New York, 1926. Price, $2.00.

This manual on art enameling is written by one who "is a descendant of enamelers, painters on enamels, and manufacturers of enamels and colors for painting on enamel—the ancient Genevan family of Dufaux," and "now devotes himself entirely to the manufacture of enamels and colors." The translator has had an experience of over forty years in the art of enameling and is no doubt accurate, but the results would be more pleasing if not so literally rendered.

The early chapters, devoted to an outline of proper quarters, equipment, and accessories, are followed by the details of enameling. The enamel is purchased in the form of "lumps or cakes." Unfortunately, nothing is given as to composition. Grinding by hand in an agate mortar and wetting with water to form a "pasty" mass are the main treatments of preparation. Noble and base metals are discussed in relation to enamel. The metal form is pickled, usually by dilute sulphuric acid. Drops of the moist enamel are applied by a "steel point" and worked together to form a continuous coat and the piece is then fired at from 600 to 800° C. Several coats are built up as desired. Numerous details regarding design and technic follow.

The final chapter covers painting on enamel. The base is a piece of metal enameled as previously described. Paintings are executed on this by the use of colors in oil ap-

plied by the brush. These are fired, one color at a time, and the finished piece is protected by firing a colorless flux. Minute details are given. (Reviewed in *Ind. Eng. Chem.*, **18** [9], 988 (1926.))

Colloid Chemistry, Theoretical and Applied. Edited by JEROME ALEXANDER. **Vol. I. Theory and Methods.** 974 pages. Chemical Catalog Co., New York, 1926. Price, $14.50.

In turning over the pages of this book, one is struck by its almost encyclopedic character and the vast amount of valuable information contained in a single volume. The book may be likened to a bound volume of the new publication, *Chemical Reviews*, in which each paper or chapter is complete in itself and deals with some special phase of colloid chemistry. The sixty chapters were written by as many students of colloidal phenomena, many of them internationally famous in the world of science. Each chapter gives a review and bibliography of the subject covered, usually, of course, with the author's own views greatly predominating. In the various chapters the ideas expressed on any one point are often refreshingly different, thus helping the reader to maintain a broader view of the whole subject.

The method employed in editing has been to insert footnotes with the editor's comments. While these may prove helpful in some instances, they appear not always to be properly informative. For example, in criticizing Michaelis's chapter, the editor comments (page 505), "This simple explanation is obviously not so, since Blasel and Matula found that *deaminized* gelatin bound about as much acid as the original gelatin with its amino groups intact," apparently unaware of the later classical work by Hitchcock, showing the quantitative relationship between the acid-binding power of gelatin and its nitrogen contents before and after deamination.

The book is extremely valuable as a collection of reviews of many phases of colloid chemistry written by able contributors to the science. It is hardly suitable as a text book, but it will be welcomed as a valuable reference work and one whose chapters, which may be read separately, as time affords, will furnish many hours of interesting and instructive reading. (Reviewed in *Ind. Eng. Chem.*, **18** [9], 988 (1926.))

The Potters and Potteries of Bennington. Issued: May, 1926. 255 pages, 44 halftone pages, 8 color plates. Binding: Apricot boards, and black buckram; black stamping. Size of edition, 750 numbered copies. Price, $20.00.

This book is divided into two parts. The first of these discusses the so-called *Norton Potteries*, founded in 1793 by Captain John Norton, of Revolutionary fame, and subsequently maintained by his sons and his grandson. Part II deals with the advent of Christopher Webber Fenton, brother-in-law of Julius Norton, and with the establishing of the United States Pottery by the former. Fenton it was whose extraordinary activity led to the manufacture of a great variety of wares at Bennington, to a multitude of ceramic experiments, and to eventual failure. Mr. Spargo's vivid narrative portrays the successive Nortons, Fenton, and his numerous associates—their appearance, their habits, their achievements. It is full of interesting sidelights on Vermont life during the first half of the nineteenth century. Above all, Mr. Spargo has been the first writer on the Bennington Potteries to verify his facts before publishing them; the first to make a really exhaustive study of the Bennington wares, and to analyze, classify, and describe their various bodies and glazes, to identify their marks, and to emphasize their special characteristics.

AMERICAN CERAMIC SOCIETY BIBLIOGRAPHIES FOR SALE

	No. of pages	Price	Postage
Branner's Bibliography of **Ceramic Literature** (1906)	451	No charge	Parcel Post only
List of Ceramic Books January Journal, 1923	26	Out of print	
Transactions of the American Ceramic Society, Collective Index	70	1.50	
Directory of Ceramic Materials	89	No charge	4½c
Enamel Index	36	No charge	1½c
Enamel Bibliography January Journal, 1921	14	$.75	
Report, Enamel Committee on Standards, with Bibliography on (a) Plasticity and Setting up of Enamel Slips (b) Enamel Tests and Methods of Control By E. P. Poste and B. A. Rice May Bulletin, 1926.	22	No charge	Parcel post
White Wares Index	47	No charge	1½c
Monograph and Bibliography on Terra Cotta By Hewitt Wilson February Bulletin, 1926	51	$1.00	
Bibliography on Flint Pebbles By F. T. Heath September Bulletin, 1925	23	$1.00	
Opal Glass Bibliography By A. Silverman April Journal, 1918	97	$ .60	
Clay Resources By H. Ries September Bulletin, 1925	92	1.00	
Magnesite and Magnesite Brick Bibliography By J. Spotts McDowell and R. M. Howe March Journal, 1920	9	.60	
Chrome Refractories Bibliography By J. Spotts McDowell and H. S. Robertson. December Journal, 1922	5	.75	
Magnesite Refractories Bibliography	41	No charge	3c
Silica Refractories Bibliography	125	No charge	6c
Complete Clay Refractories Bibliography with collective index (To be issued soon)			
Seger's Collective Writings	2 Vols.	$7.50 per volume	

Coöperation

Persons and organizations coöperate or oppose. They do not compete. A man's only competitor is himself. Progress and success depend upon effort expended and wisdom used by self and this is true of organizations.

This SOCIETY enjoys the coöperation of ceramic trade associations, commercial journals, the private and public research laboratories and the universities to the extent of its merits. When the SOCIETY merits more, a fuller coöperation will be given.

The trade associations, the universities, and the ceramic research laboratories are allied with the AMERICAN CERAMIC SOCIETY in America and with similar agencies abroad in the promotion of ceramic technology and education.

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BULLETIN

of the

AMERICAN CERAMIC SOCIETY

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Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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Vol. 5 November, 1926 No. 11

EDITORIAL

CERAMIC TECHNOLOGISTS AND CERAMIC ENGINEERS

There has been confusion in the discussions of ceramic curricula because there have been no clear definitions of the terms technologist and engineer. The Committee on Education has assumed in its critical analysis of the present day curricula requirements that the distinction between the terms technologist and engineer as used by the Committee was apparent and generally understood.

Ceramic technologists have as their work the control of quality and finish of product.

Ceramic engineers have as their tasks the plant layout, equipment, and operation.

Naturally the tasks of the technologist and of the engineer overlap and in some cases completely merge, but it requires no imagination to define clearly the distinctive character and fields of each.

The American schools of ceramic engineering are for the most part schools of ceramic technology. The graduates of these engineering schools are better equipped to serve industrially as technologists. The constructive criticism is made that since ceramic engineers are needed the so-called ceramic engineering schools should equip men to serve as ceramic engineers. The engineering courses should be most largely engineering and separate courses be provided for training of technologists.

A. S. Watts has analyzed the ceramic engineering course at Ohio State University to be as follows, showing 7% allied engineering, and 7% ceramic engineering, a total of 14% ceramic engineering as against 24½% ceramic technology.

	Per cent		Per cent
Mathematics, including mechanics	21	Allied engineering (surveying, power transmission, fuels, and pyrometry)	7
Physics, inc. heat, light, sound, and electricity	7	Fundamental ceramics	12½
Chemistry	13	Ceramic practice including laboratory	12
Engineering drawing	7	Kiln, drier, and plant design	7
English	4		100
Geology and mineralogy	4		
Elective (student's choice)	4		
Physical and military training	1½		
Total fundamentals	61½		

Members of the Committee on Education have not attempted to define their ideas in terms of curricula. The following is a suggestion for their consideration.

Suggestive Curricula for Ceramic Engineering

FIRST YEAR

Autumn Quarter		Winter Quarter		Spring Quarter	
Mathematics Plane Trignometry	5	Mathematics College Algebra	5	Mathematics Analytic Geometry	5
Chemistry Elementary or General	5	Chemistry Elementary or General	5	Chemistry Qualitative Analysis	5
Engr. Drawing Elementary Mechanical	4	Engr. Drawing Mechnical	4	Engr. Drawing Descriptive Geometry	4
English	3	English	3	English	3
Survey of Engineering Elements of Engineering	1	Survey of Engineering Elements of Engineering	1	Survey of Engineering Elements of Engineering	1
Military Science	1	Military Science	1	Military Science	1
Hygiene	1	Physical Education	1	Physical Education	1
Physical Education	1				

SECOND YEAR

Summer Quarter
Ceramic Engineer
Industrial Experience 5

Autumn Quarter		Winter Quarter		Spring Quarter	
Mathematics Calculus	5	Mathematics Calculus	5	Mathematics Calculus	5
Physics Mechanics and Heat to Conduction	5	Physics Heat completed, Sound, and Light	5	Physics Electricity and Magnetism	5
Chemistry Metallurgical Analysis	3	Chemistry Ceramic Analysis	4	Chemistry Ceramic Analysis	4
Geology Physical Geology	5	Mineralogy Crystallography and Descriptive Mineralogy	4	Ceramics Products, Materials, and Processes	4
Military Science	1	Military Science	1	Military Science	1

THIRD YEAR

Summer Quarter
Industrial Experience 5

Autumn Quarter		Winter Quarter		Spring Quarter	
Mechanics Theory and Applied	5	Mechanics Strength of Materials	5	Mechanics Strength of Materials	5
Chemistry Physical Chemistry	3	Machine Design Laboratory	3	Kinetics and Hydraulics	
Engineering Drawing	3	Steam Engineering	5	Trusses Laboratory	3
Pyrometry	2	Winning and Preparation of Ceramic Materials	5	Surveying Field and Laboratory	3
Fuels and Fuel Testing	5			Thermo Chemical Mineralogy	3
				Drying and Firing Lectures and Calculations	4

FOURTH YEAR

Summer Quarter
Industrial Experience 5

Autumn Quarter		Winter Quarter		Spring Quarter	
Power Generation and Transmission Lectures and Laboratory	5	Engineering Organization function and coordination, Production management	4	Time and Motion Study	2
Electric Furnaces High and Low Temperatures	3	Work Routing and Cost Analysis	2	Human Engineering	3
Ceramic Designing	5	Ceramic Designing	5	Ceramic Designing	5
Ceramic Products Use, Composition, Qualities and Testing, Lectures	5	Ceramic Products Testing laboratory	4	Ceramic Products Laboratory production of product for specific purpose. Test of effect of variation in materials and process. This to be elective as to product studied.	4
		Ceramic Thesis	3	Ceramic Thesis	3

Ceramic technology, or the science of ceramic product compounding, forming, and firing, requires a knowledge of (1) ceramic products: their service and market requirements, (2) the means of controlling processes, and (3) a conception of forms and decorations.

Ceramic art or the science of ceramic form and decoration likewise requires a knowledge of ceramic products and in addition an elementary knowledge of ceramic materials and ceramic compounding and processes.

A combined curricula for ceramic art and ceramic technology could be as follows:

Suggestive Curriculum for Ceramic Art and Technology

FIRST YEAR

Autumn Quarter		Winter Quarter		Spring Quarter	
Appreciation Plastic Arts	1	Pictorial Arts	1	Free Hand Drawing	5
Drawing	4	Drawing or Mathematics	4	or Mathematics	
Chemistry	5			Popular Arts	1
Trigonometry	5	Chemistry	5	Chemistry	5
English	3	English	3	English	3
Physical Education	1	Ceramic Products	4	Ceramic Materials and Mixtures for Products Specific	5
Military	1	Physical Education	1		
	—		1	Physical Education	1
	20	Military	—	Military	1
			19		—
					21

SECOND YEAR

Summer Quarter
Industrial Experience 5

Autumn Quarter		Winter Quarter		Spring Quarter	
Modeling or Physics	5	Modeling or Physics	5	Drawing from Life or Physics	5
Free Hand Drawing or Calculus	5	Elementary Design or Calculus	5	Special Design or Calculus	5
Chemistry	5	Ceramic Calculations	5	Ceramic Products	5
Physical Education	1	Physical Education	1	Physical Education	1
Military	1	Military	1	Military	1
	17		17		17

THIRD YEAR

Summer Quarter
Industrial Experience

Autumn Quarter		Winter Quarter		Spring Quarter	
Water Color Painting or	5	Special Designing	5	Technical Art Problems	5
Physical Chemistry	5	Fuels and Furnaces for Ceramic Product Making	5	Ceramic Process Control	3
Ceramic Drying and Firing		Terra Cotta and Tile Designing	5	Mineralogy	3
Ceramic Products Making and Dec.	5	Etching and Printing	4	Ceramic Product Processes	5
Mold Making	2			Elective	2
	17		19		18

FOURTH YEAR

Summer Quarter
Industrial Experience

Electives in Ceramics, Arts, Sciences and Engineering to suit talents and vocational choice of students.

Thesis 5 hours throughout year on designing, producing, and decorating a line of ceramic ware.

Thus far are considered only the general topics in curricula for ceramic engineering, technology, and art. The substance of the training is of equal importance.

The first collegiate instruction in ceramics was at Ohio State University. It was natural for Professor Orton, a metallurgist, to conceive of the course as one in engineering. The second course of instruction was at Alfred University with Professor Binns directing. Since Alfred did not have engineering courses and since Professor Binns was an artist the Alfred course naturally was most largely ceramic art. There are graduates from each of these two schools who have served equally well as engineers, others as artists, and others (the larger number from each school) as ceramic technologists. The ceramic instruction given in both of these schools has been mostly ceramic technology.

Both of these ceramic schools, Ohio and Alfred, were started at a time when there was very little literature and practically no understanding of the chemical and mineralogical constitution of ceramic materials and mixtures. The class instruction of necessity was in the

nature of original research. That this was timely and well done our present knowledge as recorded and performed amply proves.

For thirty-two years the ceramic schools have been taking their pupils over the same ground in much the same manner as they did in the beginning, whereas the demand of both the producer and user of ceramic wares is for ceramists trained to think in terms of product. Compositions and materials are essential but a general knowledge of these is now quite fully recorded.

The fact that engineers of other schools are serving equally as well as engineers in all, and better in several of the ceramic industries and that chemists with a general training in science are doing equally well as ceramic technologists in many of the largest industrial organizations is evidence of the inadequacy of the present day ceramic curricula.

The present day collegiate training in ceramic technology equips a person to serve the ceramic industries as well but no better than does the training in chemistry. The chemist has available in the literature all the ceramic information that is possessed by or is available to the ceramic graduate. In this respect they have equal advantage. Neither the chemical nor the ceramic graduate has had training for the task on which he must at once engage, that of comprehending and applying the essentials in the producing and in the using of the products which his employers make. In this the chemical and the ceramic graduates are at equal disadvantage.

Ceramic industries need engineers who know processes, equipment, and labor control with particular application to ceramic product production.

Ceramic industries need scientists trained in making application of facts known to the producing of wares of specific character and trained to conceive new products and new uses of products.

Ceramic industries need artists skilled in forming and decorating ceramic wares and possessing an elementary knowledge of ceramic products, materials, and mixtures.

The question for consideration is: could the curricula of our ceramic schools be revised with advantage alike to the graduates and to the industries? The present curricula, being as they are the result of very careful pedagogical study, cannot editorially be condemned. There has been no attempt here to present this question from any other than the viewpoint and the needs of the ceramic manufacturers.

PAPERS AND DISCUSSION

SUGGESTIONS ON CERAMIC ART EDUCATION[1]

By Frederick H. Rhead

As it is generally accepted that art development in the ceramic industries of this country has not reached the standard of decorative and creative work attained in other fields, it is not necessary to dwell in this limited paper on the lack of highly skilled American craftsmen and decorative workmen. This condition has been discussed at various meetings of the American Ceramic Society and a number of papers on this subject have appeared in the *Journal*. A fairly comprehensive review has appeared in *Art in Industry* by Charles R. Richards, which is a report of an industrial art survey conducted under the auspices of the National Society for Vocational Education and the Department of Education of the State of New York. The volume referred to was published in 1922, and the report on ceramics emphasizes the lack of experienced designers and also of educational institutions for training persons to meet art needs of the clay and glass industries.

More recently one of the directors of the Rosenthal potteries visited this country and on his return to Germany wrote an account of the American ceramic industries in the German technical publication, *Keramos*. While praising our organization methods and our ability to get out mass production Dr. Zoellner makes the statement that we do not make original designs because we are content to copy European patterns. He is evidently impressed with our technical work because he speaks very highly of our body, glaze, and glass developments.

As the training of a corps of scientific or artistic experts is a matter of a number of years it is obvious that the first step in a new industrial development is the importation of foreign specialists to provide for immediate needs. The history of ceramic development in any country will show that foreign specialists were largely responsible for the various ceramic art works of different periods. Ceramic specialists would of their own initiative or otherwise migrate from one country to another. Educational facilities generally closely followed the immigration or importation of foreign skilled specialists.

Practically all early American ceramic wares were made by foreign labor and possibly the majority of our potteries are today operated by descendants of English potters. As the industry developed into large scale production it was necessary to develop ceramic chemists

[1] Presented at the Summer Meeting, American Ceramic Society, Philadelphia, Pa., Sept. 1, 1926.

and engineers and as a consequence schools were provided for their training.

The need for technical and engineering ceramists has in the past been more urgent than the need for art specialists because it is impossible to manufacture ceramic ware on a large scale without expert technical control. In other words a ceramic manufacturer has been compelled to have technical assistance but he could for a time do without the services of the artist by copying foreign wares and by utilizing the services of foreign artists and decalcomania manufacturers who provided designs and decorations especially for the American market.

Not all American manufacturers realize or recognize the need of serious artistic development. Many are content to use a selection of ready made designs and decorations of which they have little or no part in creating. Fortunately, it is beginning to be generally accepted that to meet the critical demands of the better informed purchasers the manufacturers of glass and clay ware must possess the facilities to create and to produce goods that are distinctive and which will please. It is no longer sufficient to have ceramic technologists and engineers who can carry on or copy; our ceramic plants also need ceramic artists able to conceive and to create new products.

Any good art school can train persons to be competent artists and designers, but these have not, and, without special application, cannot meet the demands which have come to us for ceramic artists. A skilful designer and decorator would be of little or no value in the average ceramic plant if he possesses no practical knowledge of ceramic processes and materials.

The complexities of ceramic work are such that no individual can know too much about shop processes but it should be obvious that a ceramic art student should not spend considerable time in studying other phases of ceramic ware production at the expense of fundamental knowledge of art except if he should intend to be a ceramic technologist. We need men who are first of all finished artists and craftsmen, with a comprehensive knowledge of historical ornament who can draw and paint and who possess a practical knowledge of the various decorative processes. And we need ceramic technologists with sufficient training in the fundamentals of art to be able to vision the possible use of the knowledge there is of ceramic materials, mixtures, and processes in the development of new products.

While the fundamentals of design and decoration are much the same in all branches of ceramic work, the practical and decorative processes are quite different. An artist or decorator working in a tile or terra cotta plant is doing a totally different type of work than the decorator employed in a dinner ware plant. A ceramic art school should therefore give in the first two years the fundamentals in art and ceramic tech-

nology and provide electives for those who wish to specialize the remaining two years.

In the English and continental schools the art and technical courses are entirely separate. The technical student has every opportunity to acquire an appreciation of the artistic side of ceramics and the ceramic artist and designer is given a general understanding of the technical side of the work. The courses of study for the ceramic art students in the English government schools include: (1) decorating and designing, (2) drafting, (3) modeling, (4) engraving, (5) decalcomania process, (6) enameling and gilding, and (7) architecture.

These are carefully graded fundamental courses for which examinations are held annually. The various decorative processes are taught as a matter of course in relation to the particular problems under execution.

A closer and more thorough knowledge of the decorative processes is gained in the factory but as few plants have more than one or two decorative processes, it is very difficult for a student to acquire in a plant a comprehensive knowledge of the decorative methods unless these are taught in the schools. It is most important, therefore, that there should be a general course including the most commonly used decorative processes.

The English ceramic art student generally acquires considerable plant experience. Practically all the English government art schools are open at night providing an opportunity for pottery workers of all grades to study any branch of ceramic work in which they are interested. The English and continental student enters art school when he is anywhere from ten to thirteen years old, and his association with the school will last for a period of not less than ten years.

Each course is planned according to the needs of the industry and is pretty much the same all over the country. Students who leave one locality may enter another art school and continue their studies without interruption. Government examinations are held annually, and all work done in the examination period of two months or more is forwarded to South Kensington from where all grades and diplomas are awarded. An advanced student will take from twelve to twenty examinations on different subjects in one year.

Unless the possibilities for development work are fully understood, manufacturers, such as those interested in table ware, may easily be of the opinion that any decorative work not in use in their particular plant may be unprofitable, when as a matter of fact various decorative methods can be used in the production of every type of ceramic ware requiring a decorative shape or design. Inasmuch as decorative skill requires practice, it is essential that the decorative man have a thorough

knowledge and experience with the commonly practiced decorative processes.

The research work of the decorative ceramist should be confined to execution and not to development work in bodies, glazes, and colors. Because the work of the decorative ceramic specialist deals almost entirely with execution, a university course must be one that will permit continuous and consistent production. A student taking an art course in sculpture or painting must spend the major part of his time in productive work if he expects to acquire necessary technique. He is not so much concerned about the chemistry of his colors or the manufacturing processes of his brushes, tools, or other equipment. His lecture courses should deal chiefly with historical data and with subjects directly related to technique and execution.

On the other hand the ceramic technologist should have lectures and laboratory work principally in production methods and his researches should be a classification and analysis of the materials and mixtures required to produce wares of specified quality.

If these ideas are acceptable, the student would then enter a ceramic art school which offers instruction in the production of the various types of ceramic ware now being produced and sold for the American market. Such a school then, would have on file and properly classified, a comprehensive series of formulas covering bodies, glazes, slip colors, underglaze and overglaze colors, lusters, etc., with fired samples for purpose of comparison and selection.

All this information would be available to every student. In the course of time the school would accumulate examples of various ceramic types, each example having a comprehensive description of processes, including all formulas and giving the source of supply of all materials.

A typical production program for one year may be about as follows:

1. A full size doorway or window terra cotta scheme showing decorative possibilities under industrial plant conditions.
2. Faience scheme showing floor and wall tile treatments and two or three faience fountains or other objects suitable for the embellishment of a building or garden.
3. Dinnerware services showing possibilities in hotel and general utilitarian wares.
4. Ornamental art wares in various decorative processes.
5. Utility and decorative glass and glass enameled ware.

The student would produce these wares under the supervision of the instructor who obviously must be a craftsman with a knowledge of the known practical processes.

The program such as outlined above involves and is related to the three following organization activities:

1. Design, decoration, and specifications. This covers the making of original designs, and the working drawings for the various objects

to be made. Under ideal conditions such instruction would be given in the fine arts department of a university under the supervision of an instructor who possesses a knowledge of architectural details in addition to being a competent designer.

2. Technical. Preparation of bodies, glazes, and colors. The working drawings prepared in the art department would specify certain bodies and glazes, and the decoration would require a number of colors and glazes of various textures.

3. Practical and decorative. The ceramic art student is now supplied with the designs, working drawings, specifications, and materials, and is in a position to begin production on the various wares outlined.

The practical processes involved for pottery and tile are as follows:

Modeling The execution of the original models in plaster, clay, wax, or other materials commonly used in the industry.

Block and Cases The making of key molds from which quantity production of molds is made.

Mold Making Practical mold making for the various industrial processes such as casting, pressing, and jiggering processes.

Bisque Kiln Placing and Firing Placing of bisque wares of various types, particularly in relation to high temperature products and heavy clay wares to provide against such troubles as warping, dunting, and cracking.

Glazing The two most commonly used methods of glazing by dipping and spraying should be practiced by the art student.

Glost Kiln While somewhat like to the bisque process, glost kiln management is much more complex, because a glazed product cannot have the same degree of support in the kiln.

As university kiln equipment is limited, the difference between school and factory production would be noted. It is only essential that the school have a well-designed kiln capable of being manipulated at temperatures from cones 01 to 16. A rectangular kiln about 5 by 4 by 5 feet convertible to a muffle kiln and fired by gas, oil, or coal with control equipment commonly used in the industry would be quite satisfactory for all work related to the pottery and tile industries.

The activities outlined in the foregoing include only the essential practical processes used in manufacturing pottery and porcelain products and do not include the decorative processes. The chief decorative processes for pottery, tile, and terra cotta may be broadly grouped as follows: (1) decorations in the clay state, (2) decorations in the bisque state, (3) glazed decorations, and (4) overglazed decorations.

The clay processes embrace decorations in high and low relief, both with and without colored slips. Clay processes as a rule are more appropriate for architectural faience, tile, and art wares although most interesting effects have been attained in utilitarian wares with colored slips. The clay processes which should be included in a ceramic art course are incised, sgraffito, painting in colored slips, and flat color decorations.

The underglazed processes include decorations in colors applied directly on the bisque or over the unfired clay. Underglaze decalcomania would be included in this. The decorations directly on the bisque are more appropriate for utilitarian art ware while the decorations on the unfired glaze are suitable for architectural schemes in faience and tile.

The overglaze processes include types of decorations appropriate for mass production. The students taking a course in overglaze ceramic design and decoration would be qualified to take a position as a designer or art director in the white ware factories.

The glazed processes include the various methods of glaze painting and manipulation, inlay processes, raised line work, and other methods of glazed decoration. The glazed processes are used in the production of terra cotta faience tile and art wares.

In considering any fundamental course of study for the ceramic decorative processes it must be recognized that the various ceramic products are fired in widely varying temperature ranges involving at least four or five different bodies and from ten to twenty different base glazes. The temperature range for terra cotta may be from cones 03 to 6. The range for faience and art ware is from cones 1 to 11. The range for porcelain products is from cones 9 to 16 and the dinner wares range from cones 6 to 9.

A partial list of the ceramic decorative processes are here given to show the varied methods used in pottery, tile, and terra cotta.

DECORATIVE CLAY PROCESSES

Incising, modeling
Flat relief treatment
Colored slip decoration, English school
Colored slip decoration, French Barbatine school
Slip decorations, Rookwood school
Slip decorations, Copenhagen school
Modern slip decorations, pâte-sur-pâte

OVERGLAZED DECORATIONS ON BISQUE

Naturalistic decorations on white and colored bodies
Figure decorations
Decorations under colored glazes
Decorations over tin enamels, Italian, Spanish, and Delft schools

Modern underglazed decorations over matt glaze
Underglazed decalcomania

GLAZED DECORATIONS

Italian majolica	Chinese polychrome
Persian decorations	Modern decorations

LUSTER PROCESSES

Massier processes	Reduction of copper

OVERGLAZED DECORATIONS

Decalcomania	Copper plate engraving
Gilding	Etching

With courses of these kinds a ceramic art school could train artists with a working knowledge of ceramic technology and could train the ceramic technologist with a working conception of art. With elective courses that permit of specializing, such a school would meet the demand that is now being made for men who can create and produce ceramic ware having distinctive merit.

AMERICAN ENCAUSTIC TILING COMPANY
ZANESVILLE, OHIO

WHAT IS ART?[1]

BY R. GUY COWAN

The importance of art in industry is quite impossible of over-emphasis. The function of art is to give pleasure to the possessor. To increase the salability of an article, increases the pleasure its owner takes in its possession. The future well being of this country depends as much on its artistic development as it does on its good fortune in possessing so large a portion of the world's raw materials. This is true first as a matter of the happiness and contentment of its people, and second in real dollars and cents. When it comes to world commerce this question of design or art ranks in importance, first, with how much does it cost and, second, how well will it sell. Usually it costs no more, and sometimes less, to make an article beautiful than ugly. Why not make it beautiful, if it costs no more, and sells more readily at a higher price?

The *Wall Street Journal* says that it is high time that the American manufacturer realized that the easiest and best way to enhance sales values is by proper design, and cites an illustration that the industrial success of the French nation is due almost entirely to the thought and study they have given to design. The French products are marketed at a good profit all over the world for no other reason than being of good design.

[1] Presented at the meeting of the Northern Ohio Section, AMERICAN CERAMIC SOCIETY at the Association of Chemical Equipment Manufacturers Exhibit, May 13, 1926, Cleveland, Ohio (Ceramic Day Session).

It is comparatively easy to understand the importance of the sales value of good design in automobiles. Certain companies would not have risked the trouble they have had by copying Packard radiator and hood designs if they did not consider a good design essential. Why not hire a good designer and get a better model? The quite marvelous progress which the furniture industry has made in the last ten years is another good example of the intelligent use of art in industry.

To return to fundamentals: What is art? How many have really formed a fairly definite idea of what art is. It is to be doubted whether very many people have. I have been studying and talking with artists for some years, and must confess that I could not define art and have never been able to run across a person who could define it to my satisfaction. There are some things which I am satisfied that art is and certain other things that I am certain that art is not.

There are no yardsticks for art measurement. There are no multiplication tables to form the base of the vast structure of thought and fact as serve in mathematics.

In a general sort of way art is the means by which one person can re-create in the minds of others the emotions he experiences.

The chief function of art, however, is the ability to give pleasure and here is the point at which opinions begin to differ as to what is real art. All of us have our peculiarities and hobbies, and things in which we get the most extreme pleasure while others live entirely cold and unimpressed by these same things. And most of us are quite sure that the other fellow is a little bit off when he does not take pleasure in the same things we do.

To the critic in literature the sentimental story in which the ordinary person takes delight is perfectly horrible, terrible trash. It is the same all through the various types of art, that the real art and real critic have a perfect hatred of sentimentality, of things which are merely pretty.

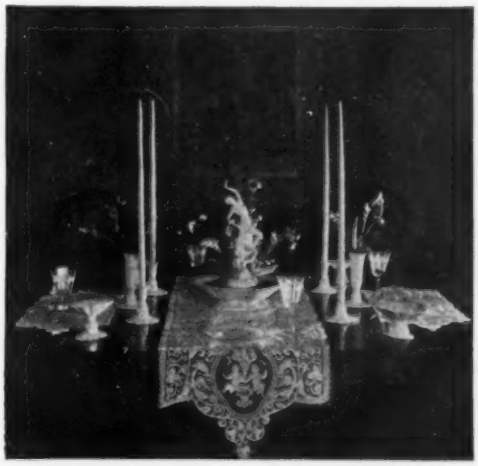

FIG. 1.

As a result of this, modern art has concerned itself too largely with things which are morbid and brutal in pure reaction to the general sentimentality on the subject. Much of this work is carried to such a degree that it makes almost as bad an impres-

sion on an artist as it does on those who are not artists. Such art is for the artist and should be confined to this class, there being no reason why the average person should be expected to find pleasure or take any enjoyment in it. That does not necessarily mean it has no use or purpose. For example, most persons had many a laugh and vented considerable ridicule over the cubistic pictures which were printed in all the magazines and newspapers a year or so ago. I felt just the same way about them, but have had to change my ideas somewhat. One of my artist friends, a painter, has shown me quite clearly where by his study of such work, and practice of it in private, he has greatly improved the beauty and power of his work. This chap paints pictures which all would admire even though few would completely understand their intent and purpose. He won the first prize for the finest picture in the exhibition this summer at the Cleveland Museum of Art.

We have been too narrow in passing judgment of things we do not understand. Work of this kind bears the same relation to the public welfare that polar exploration does. The public cannot see its value. On the other hand these ultra-modern artists have been too narrow in expecting the public to admire, and most of all to pay good money for that which is artistic only to the artist.

It is essential to have a little more tolerance and a little more understanding of modern art.

Art is not an imitation of nature. To paint a landscape as perfect color photography would show it, is not art, it is merely good workmanship. To model or sculp a beautiful human figure no matter how well the work is done is not art. To take a plaster cast of a human figure is just as much art as to model it perfectly free hand. Something more is needed than a surface reproduction to take it out of the realm of skilled workmanship and into that of art.

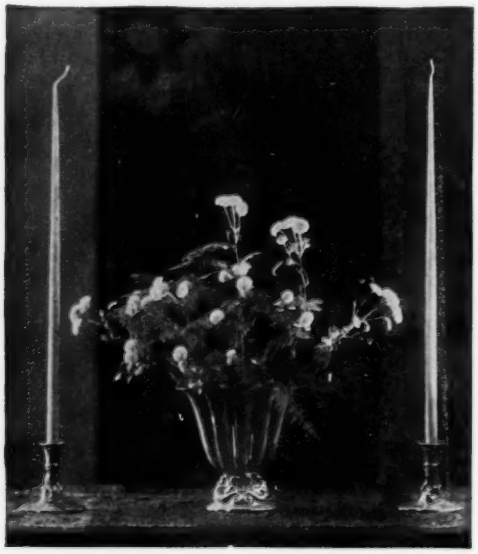

FIG. 2.

The painter artist sees in nature something that pleases him. What he sees has a distinct emotional reaction on his mind. What he now strives to do is to construct on his canvas a combination of line, design, and color

which will re-create in the minds of others the same emotion or impression. To do this the artist may have to take some liberties with what the camera might say was the truth with that particular bit of nature. If it was a real work of art, he would not, however, have had to falsify nearly as much as the camera would be forced to do. I have seen a great many camera pictures of so-called terrible storms at sea, but I have never seen one which gave me much of a thrill or looked terrible. In most cases the camera falsifies. It rarely records the human impression of a scene from nature; it just gives an inventory.

Art is not skill. Some of the greatest works of art in the world are not skilfully done. We cannot here go into this at length but we might mention as an example, Millet's "The Sower." There are several who can paint more skilfully and better, but in the minds of the art world they have not produced a work as great. Millet had less skill with the brush than have many lesser artists. If he had it, he did not use it. He was concerned merely with getting across the emotional quality he felt in this big hulking peasant at his eternal task. There is a large amount of skill exhibited in this picture but it is not evident; it is submerged in an indefinable quality, much greater, which puts it across.

Artists are accused of being of necessity impractical. The best of artists are real "he" men, and as practical as men in other walks of life. Some of the great artists like Michael Angelo were great all-round men. Michael Angelo was the greatest painter and sculptor of his period, some think of all time. He certainly was the ablest engineer of his period; he designed and constructed war machinery such as catapults and defensive machines for the protection of walled cities; he built public buildings and fortified the city of Florence. Leonardo da Vinci was another great man, an inventor and engineer, and a man of real practical affairs, but first of all one of the greatest artists who ever lived. Either one of these men I would consider the greatest all-round man of his period.

The great difficulty the manufacturer has who needs the services of an artist is to select a capable artist. He has to choose from among the many who pass as artists and are not. It would be rather amusing to hear some of the troubles that even the critics and museum authorities have in deciding what is art and what is not. The Cleveland Museum each year has an exhibition for work of all kinds from the Cleveland district. The Museum makes an effort to set a high standard for this exhibition. They, therefore, get as a jury three nationally known artists and critics to act as judges. This year fourteen hundred works were submitted to the jury out of which they picked six hundred as being acceptable. The eight hundred works which were turned down I venture to say would make a very creditable exhibition.

For several years the Pennsylvania Museum of Art in Philadelphia has held a national exhibition. To this they have invited the Cleveland Museum to send the best things locally produced. The Pennsylvania Museum, however, has another nationally known jury of art critics. A portrait was sent by the Cleveland Museum, but was judged by the Philadelphia jury as not being worthy of showing at their Exhibition. On the other hand the silver work of an artist was turned down by the Cleveland Museum as not being of a high enough standard for local exhibition. This chap, however, has a national reputation, was invited by the Philadelphia Museum to exhibit, and the jury gave him first prize for the identical piece which had been rejected by the Cleveland jury.

You will probably say that if the critics having a national reputation are unable to agree on what is good, what should the layman be supposed to know. Of course there are many things on which they would agree but I have decided that each person has a right to his opinion as to what is good and what is bad, provided each one keeps an open mind on the subject. The one thing on which all of these judges would agree was in poor taste was something which was sentimental or merely pretty.

Ceramic Art

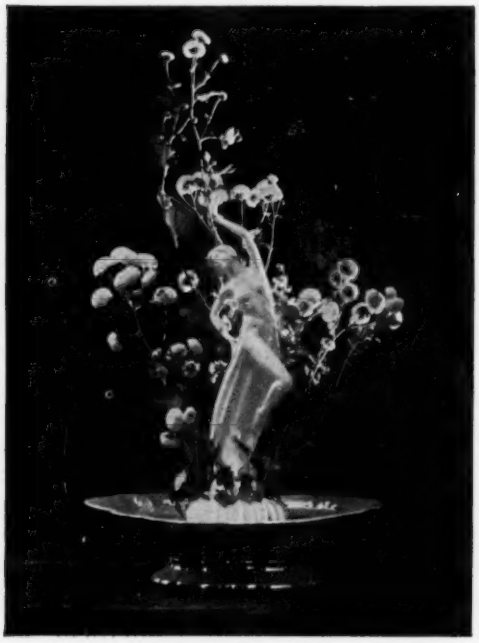

FIG. 3.

The greatest handicap the ceramic artist has on graduation is to visualize the importance of his work from the standpoint of the public. After studying for several years, and working with glazes and colors, there are a great many things that interest the student but which have absolutely no meaning to the public. Take for example crystal glazes. I know of no one thing more fascinating to the ceramist than the amazing variety of effects possible in crystalline glazes. Their interest is due first to the unexpectedness of the results and to the pleasure one can get in a closeup

study of their textures, and to the minute variation of color. The public, however, will see a vase with a crystal glaze only as it looks in the large. They see the general color, and they think of it in relation to the part it would play in the decoration of a room. They have no interest in picking the piece up, and making a close study of its texture and of its variations.

The things the young ceramic artists must study and make use of are (1) line and form and (2) general color effect. The questions of quality and texture of glaze are important in that they affect the general decorative result of the piece. It is difficult for the student to see a contemplated production in actual use. They see the glaze or the color but they do not see the piece as it will be used. They should be able to produce ceramic bodies, glazes, and colors but of greater need is the ability to conceive and produce ceramic wares with these points, which will pleasingly convey to the purchasing public the creative emotions by which the wares were conceived.

It is important, therefore, that the public as a whole build up an interest in art, form opinions of what is good and what is bad so that out of this interest real progress may be made in taste and appreciation. An increased interest and appreciation of art with its consequent utilization in industry is one of the most important factors in the industrial development of this country. The illustrations make a little more concrete some of the things here discussed in an abstract way.

THE COWAN POTTERY STUDIO
ROCKYRIVER, OHIO

SHIVERING[1]

BY W. J. STEPHANI

During the past year we have passed through an experience in glaze shivering. The factory practice which we followed to make a correction will be described.

The phenomena was relatively new in my experience, at least the general development of the condition as it appeared in this case. I am not prepared to say whether or not this shivering of the glaze was brought on by clay which had been weathered.

Without warning and in spite of the fact that fired test trials of all clays which we glazed did not show unusual tendency to shivering we were suddenly confronted with full glaze and matt ware coming from

[1] Presented at the Annual Meeting of the AMERICAN CERAMIC SOCIETY, Atlanta Ga Feb., 1926. (Terra Cotta Division.) Received June 24, 1926.

the kiln with a tendency to peel on rounded convex surfaces. The next kiln showed first signs of shivering on the high lights of ornament in full glazes, and a peeling tendency but no shivering in the glaze.

Changes in Glaze to Correct Shivering

Considerable ware of this body was made up so that it was necessary to overcome the condition by changing the full glazes and matts.

Trials were made by reducing the china clay content 5 and 10% in the full glaze batches. The same trials were made in matt glazes. While the matt had shown no shivering we thought it best to try out china clay reduction in matt glaze in case shivering appeared.

Trials of these glazes showed that a reduction of 5% china clay corrected the shivering in the full glaze without affecting the color or gloss. While the glaze with 10% reduction in clay showed no shivering it was not completely fused.

In the matt glaze trials it was found that reduction of 5% of china clay so reduced the fusibility of the glaze that the internal angles in moldings and ornament would not heal properly. Reduction of 2½% of china clay in the matt glaze entirely overcame the peeling of the glaze without reducing its fusibility. The 5% reduction in china clay in full glazes and 2½% reduction of china clay in matt enable us to put the ware already made up into the kiln.

This solved the problem in the white glazes only. Where colored glazes were involved the colors were affected by reduction of china clay so we had the problems of matching our own colors.

As can readily be seen the above procedure would only be desirable to follow insofar as it was necessary to take care of the work already pressed when the trouble started.

Body Changes

The more desirable procedure was to find the clay causing the trouble and eliminate this from the body. A body was being used consisting of one Maryland and two Jersey clays and the usual percentage of grog.

Trials made up of each of raw clay and glazed had shown no unusual tendency to shiver although slight indication could be found in two of the raw clays.

Trials were made up of body batches each of two of the three clays. These were glazed and fired. These trials showed that in each case where a certain clay was eliminated good results were obtained with the same glazes that gave trouble when the third clay was present.

It was therefore fairly conclusive that the trouble was being caused by the presence of one certain clay and that by eliminating this clay

from the body the same glazes which shivered when the clay was present in the body could be used without causing shivering.

Of course, the question of shrinkage, warping, and several other requirements that a terra cotta body must meet had to be met and answered but we found a third clay which met these requirements when mixed with the two free from shivering. The body mix was changed for all glaze work.

O. W. KETCHUM TERRA COTTA WORKS
CRUM LYNNE, PA.

GAS-FIRED ENAMELING FURNACES: COMPARATIVE RESULTS OF INTERMITTENT SEMIMUFFLE, AND FULL MUFFLE TYPES[1]

BY H. H. CLARK

There are three types of gas-fired enameling furnaces in use at the present time: the intermittent, the semimuffle, and the full muffle types.

The intermittent type gas furnace for vitreous enameling cannot be used to advantage in connection with double door furnaces, speed forks, or conveyer, or continuous furnaces. Therefore it has a very limited field of usefulness.[2]

The intermittent furnace is of greatest value in a shop where there is a large variety of work to be done, such as color work, sheet steel, and cast iron. The temperature can be raised or lowered in much less time than in any other type of furnace. The fusion of enamels on metals at a falling temperature is beneficial on some delicate color work, and the positive absence of furnace gases insures brilliant gloss on the ware.

Semi- and Full-Muffle Gas Fired

The following results were obtained at the plant of Cribben and Sexton Company, Chicago. This Company manufactures "Universal" and "Home" stoves, ranges, and heaters. Most of the work handled in the enameling department is 18, 20, and 22, gage sheet iron, although some of the parts are cast iron. All work is given three coats. The ground coat is fired on at 1650°F and the finished coats at 1580°F.

This Company first tried gas-fired furnaces for vitreous enameling about seven years ago, and at present have one 4- by 10-foot semimuffle, one 5- by 12-foot full muffle (formerly a 4- by 10-foot intermittent) and five, 4- by 4-foot semimuffle. Another 5- by 12-foot full

[1] Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Atlanta, Ga., Feb., 1926. (Enamel Division.)

[2] See H. H. Clark, "New Type of Gas-Fired Vitreous Enameling Furnace," *Jour. Amer. Ceram. Soc.*, 5 [8], 478 (1922).

muffle furnace is under construction. All these furnaces are fired with gas purchased from The Peoples Gas Light and Coke Company of Chicago. They also have two, 4 by 10, coal-fired furnaces which will soon be replaced by gas furnaces.

The fact that all of the data, on all three types of furnaces, were obtained in the same plant, under identical operating conditions, makes the comparison of more value than if obtained in separate plants.

The 4- by 10-foot intermittent furnace averaged 10 heats per hour or 200 square feet of ware, with a gas consumption of 1640 cubic feet per hour, actual average operating conditions.

The 4- by 10-foot semimuffle furnace averaged 15 heats per hour or 300 square feet of ware, with a gas consumption of 1200 cubic feet per hour.

This same 4- by 10-semimuffle furnace, equipped with speed fork, averaged 22 heats per hour or 440 square feet of ware, with the same gas consumption of 1200 cubic feet per hour. The lower gas consumption per square foot of ware, is due to the fact that when running 22 heats per hour instead of 15, the tools are in the furnace much longer and do not get as cool between loads. With some types of speed forks, the racks remain in the furnace, and as the racks or tools frequently weigh ten times as much as the ware, this saving of heat is important.

This same 4- by 10-furnace equipped with full muffle, used 10% more gas for the same production. This is to be expected because about 200°F higher temperature is necessary in the flue gases of the full muffle furnace, than in the semimuffle flue gases, to maintain the same temperature in the working chambers about 1900°F on the full muffle furnace and 1700°F on the semimuffle, for a working chamber temperature of 1650°F. However, as the heat in the flue gases is used, this excess gas consumption is not lost.

Both the semimuffle and full-muffle furnaces have automatic temperature control and recording pyrometers. The intermittent furnace had recording and indicating pyrometers, but no automatic control.[1]

As to which type of furnace is best, is a matter for local conditions to determine, although generally speaking, in a large enameling shop having more than one furnace, or a continuous process with a conveyor furnace, the semimuffle type is best, because it is lowest in first cost, lowest in operating expense and lowest in maintenance, per unit of production.

With gas fuel and a well-designed furnace, there is no need for the full muffle.

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[1] H. H. Clark, "Gas-Fired Enameling Furnaces without Muffles," *Jour. Amer. Ceram. Soc.*, **8** [10], 623–25 (1925).

ACTIVITIES OF THE SOCIETY

THE MEMBERS ARE ACTIVE

Annual Meeting The Annual Meeting in Detroit next February 14 to 19 inclusive, Book-Cadillac Hotel, has every evidence of being the best yet from the standpoint of program and attendance.

The Divisions are well along with their programs, two of them having theirs complete. Several papers are in for preprinting. Will you make known the paper you will present?

The Committees are working on plans which will be productive of better coördination in effort and greater knowledge of the fundamentals.

The local committee has plans matured to meet the desires of the delegates and that is some task considering the many plants and places of interest in and about Detroit. A. P. Ball and W. A. Carter have their committees in fine fettle.

Our Journal As a working tool the *Journal* is said to be growing in interest. Judging from the increase in subscriptions and in the offers of collaboration it must be conclued that the *Journal* has obtained an enviable world-wide as well as a national reputation. This reputation reflects credit on the members of the SOCIETY for the *Journal* is simply an evidence of the work of the members of this SOCIETY.

Refractories Bibliography A book of 132 pages text material of 880 titles and abstracts of the world's literature up to 1926 in addition to a full cross reference index is in page proof and should soon be out. For information and inspiration, condensed and indexed, this is the best the SOCIETY has yet sponsored. The Refractories Division and the ceramic instructors at the University of Illinois deserve a lot of credit for this large piece of work.

The cost of printing and issuing of this Bibliography must be borne by subscription and by money received from advertising. The Refractories Division is offering space for advertisements at the rate of $60.00 per page and are underwriting individually with $10.00 subscriptions. Several pages of advertisements are already requisitioned and several donors have sent in their $10.00 for underwriting of the expense of this publication.

Have you done your bit by offering space to possible advertisers and by an underwriting subscription?

NEW MEMBERS RECEIVED FROM SEPTEMBER 16 TO OCTOBER 16

PERSONAL

Hugo Ackermann, Bahnhofstrasse 42, Bonn, Germany.
B. S. Andrews, student, 1103 W. Illinois St., Urbana, Ill.

George J. Bair, student, Alpha Sigma Phi House, State College, Pa.
William G. Baranowski, student, 1204 W. Green St., Urbana, Ill.
Eugene C. Clemens, student, 108 E. Daniel St., Champaign, Ill.
Frederick B. Lawrence, secy. & gen. mgr., North American Mfg. Co., Box 148, Newell, W. Va.
Dan McPhail, The American Clay Forming Co., Tiffin, Ohio.
James E. Maurey, student, 708 E. College Ave., State College, Pa.
Richard P. Moeller, 1109 Paulina St., Oak Park, Ill.
Howard L. Northam, student, 603 E. White St., Champaign, Ill.
Robert Pearson, chief chemist, Detroit City Gas Co., 415 Clifford St., Detroit, Mich.
David T. Shaw, student, 404 Matthews Ave., Urbana, Ill.
Karl W. S. Smith, student, 1304 W. Stoughton St., Urbana, Ill.
Carl E. Sodergren, secretary, Minnesota Clay Works, 3212 Dupont Ave. So., Minneapolis, Minn.
Kenneth B. Strong, Enameling Dept., Federal Electric Co., 7611 Oglesby Ave., Chicago, Ill.
Benjamin W. Vaughn, supt. plant construction, Detroit City Gas Co., 415 Clifford St., Detroit, Mich.
W. J. Westphalen, vice-pres. and gen. mgr., Laclede-Christy Clay Products Co., 1673 Railway Exch. Bldg., St. Louis, Mo.
Monroe L. Wexler, student, Sigma Tau Phi, State College, Pa.

CORPORATION

H. C. Spinks Clay Co., Miners & Shippers, Ball sager, and wad clays, R. B. Carothers, representative, 52 Monmouth St., Newport, Ky.

Membership Workers' Record

	PERSONAL		PERSONAL	CORPORATION
A. I. Andrews	2	A. N. Outzen	2	
A. V. Bleininger	1	W. A. Preische	3	
R. B. Carothers				1
L. C. Hewitt	1	Samuel Rusoff	1	
R. K. Hursh	3	W. J. Scott	1	
T. N. McVay	2	Office	2	
			—	—
		Total	18	1

NEWS FROM MEMBERS OF THE SOCIETY

The American Potash and Chemical Corporation has been organized and takes the place of the former American Trona Corporation. The firm is located at 233 Broadway, New York City.

Robert J. Anderson has moved from Cleveland, Ohio, to 2416–38 Beekman St., Cincinnati, Ohio.

Elbridge J. Casselman, of Mellon Institute, Pittsburgh, Pa., is spending his vacation in France and Belgium visiting glass and clayware factories.

Ralph E. Hanna is now with the Flint Faience Tile Co., Flint, Mich.

Frederick G. Jackson has removed to 2340 Park Ave., San Diego, Calif.

The name of the **Johnson-Porter Clay Company** of McKenzie, Tenn., has been changed to the **Mandle-Porter Clay Company** and is now located at Paris, Tenn.

C. H. Kerr has lately become works manager, of the Brown Instrument Co., Philadelphia, and has removed from Wildwood, N. J., to 114 Township Line Rd., Jenkintown, Pa.

C. E. Lampe has changed from the Federal Terra Cotta Co., Woodbridge, N. J., to the Conkling-Armstrong Terra Cotta Co., Philadelphia, Pa.

Harry Longbotham has moved from Berkeley, Calif., to Burlingame, Calif., where he is connected with the West Coast Mfg. Co.

L. M. Merritt, of the Barnebey-Cheney Co., of Columbus, Ohio, is in the Philippine Islands on business for his firm.

C. P. Nye has moved from Beaver, Pa., to Mansfield, Ohio, where he is associated with the Barnes Mfg. Co.

Max Y. Seaton, formerly with the California Chemical Corporation, Chula Vista, Calif., is now with the Sierra Magnesite Co., Porterville, Calif.

A. A. Van Cleave, of St. Louis, has removed to 738 S. Highland Ave., Los Angeles, Calif.

Jack H. Waggoner, of Charleston, W. Va., has recently joined the staff at Mellon Institute, Pittsburgh, Pa.

Edward R. Walsh, chemist for the Louisville Fire Brick Works, Louisville, Ky., has removed to 102 Logan Court, Raleigh, N. C.

NORTHERN OHIO SECTION MEETING

The Northern Ohio Section of the AMERICAN CERAMIC SOCIETY held a dinner-meeting at the Winton Hotel, Cleveland, on September 20. The officers elected were: Fred S. Thompson, Chairman, F. S. Markert, Secy. and Treas., W. V. Knowles, Chairman of Membership Committee.

It was unanimously voted to accept the invitation of the Chicago section to meet with them on November 19, at Urbana, Illinois. The St. Louis section will also be present. Arrangements have been made for a private pullman to leave Cleveland on November 18 at 5:50 P.M. on the Big Four and reach Urbana in the early morning. This car will stop over in the yards and will be used as the hotel on the night of the nineteenth. Friday is to be devoted to the regular sectional program, Saturday morning to an inspection of the University, and Saturday afternoon to the Ohio State-Illinois football game. Fifty dollars will cover the trip.

The Northern Ohio Section will hold its next dinner-meeting at the Winton Hotel, Cleveland, on the evening of November 1.

MIDLAND SECTION MEETING AT URBANA, ILLINOIS

There will be a joint meeting of the Chicago, Northern Ohio, and St. Louis Sections of the AMERICAN CERAMIC SOCIETY at the University of Illinois, Urbana, Illinois, on November 19, 1926, afternoon and evening.

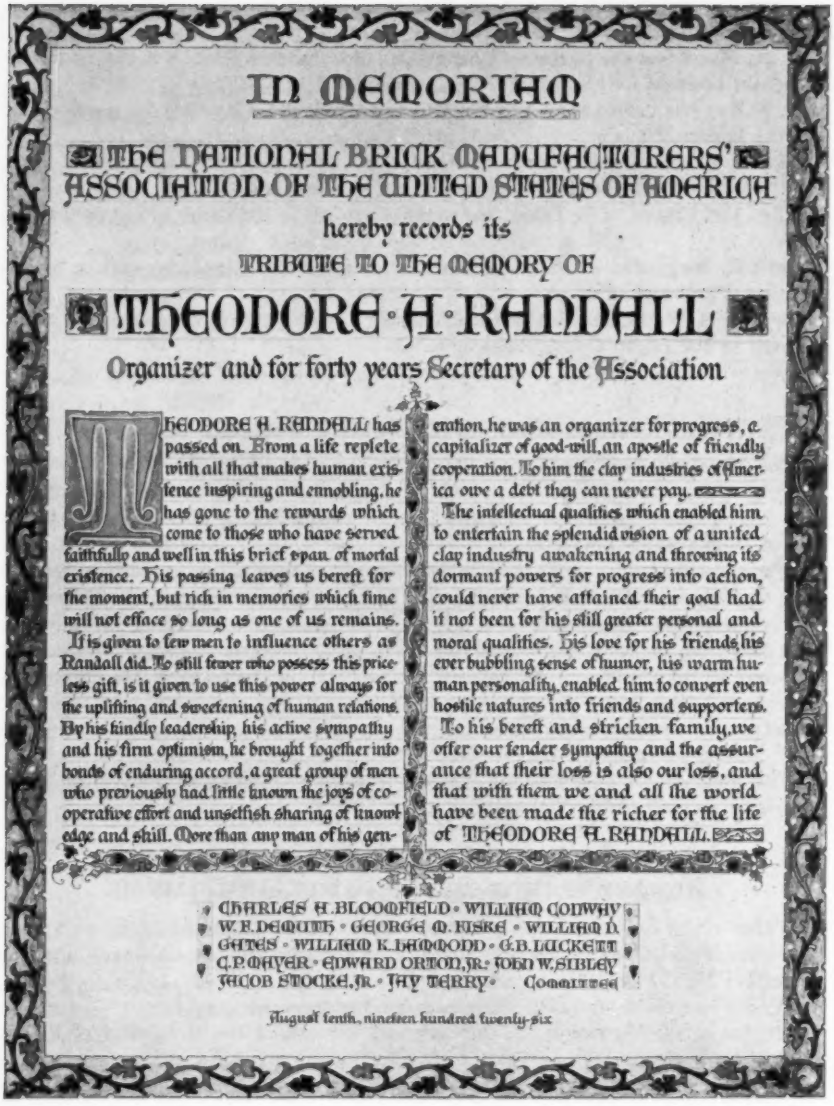
A very interesting and instructive program has been prepared.

On Saturday, November 20, the members will attend the University of Illinois-Ohio State football game.

Adequate transportation is being arranged. Sleeping accommodations at Urbana and tickets for the game must be secured in advance; therefore it is imperative that members advise the Secretary of their attendance.

This is an opportunity to visit the University of Illinois, to meet and confer with University officials, and members of the Chicago and Ohio Sections, to take part in a special program with attendant educational discussions, and to see the famed University of Illinois and Ohio State football stars in action.

The members are asked to notify G. D. Lake of the Parker-Russell Mining and Manufacturing Company if they are planning to attend this Meeting.



IN MEMORIAM

THE NATIONAL BRICK MANUFACTURERS' ASSOCIATION OF THE UNITED STATES OF AMERICA

hereby records its

TRIBUTE TO THE MEMORY OF

THEODORE · H · RANDALL

Organizer and for forty years Secretary of the Association

THEODORE H. RANDALL has passed on. From a life replete with all that makes human existence inspiring and ennobling, he has gone to the rewards which come to those who have served faithfully and well in this brief span of mortal existence. His passing leaves us bereft for the moment, but rich in memories which time will not efface so long as one of us remains.

It is given to few men to influence others as Randall did. To still fewer who possess this priceless gift, is it given to use this power always for the uplifting and sweetening of human relations. By his kindly leadership, his active sympathy and his firm optimism, he brought together into bonds of enduring accord, a great group of men who previously had little known the joys of cooperative effort and unselfish sharing of knowledge and skill. More than any man of his generation, he was an organizer for progress, a capitalizer of good-will, an apostle of friendly cooperation. To him the clay industries of America owe a debt they can never pay.

The intellectual qualities which enabled him to entertain the splendid vision of a united clay industry awakening and throwing its dormant powers for progress into action, could never have attained their goal had it not been for his still greater personal and moral qualities. His love for his friends, his ever bubbling sense of humor, his warm human personality, enabled him to convert even hostile natures into friends and supporters.

To his bereft and stricken family, we offer our tender sympathy and the assurance that their loss is also our loss, and that with them we and all the world have been made the richer for the life of THEODORE H. RANDALL.

CHARLES H. BLOOMFIELD · WILLIAM CONWAY
W. E. DEMUTH · GEORGE D. FISKE · WILLIAM D. GATES · WILLIAM K. HAMMOND · G. B. LUCKETT
C. P. MAYER · EDWARD ORTON, JR. · JOHN W. SIBLEY
JACOB STOCKE, JR. · JAY TERRY · Committee

August tenth, nineteen hundred twenty-six

FIG. 1. Facsimile of tribute to the late Theodore A. Randall by the National Brick Manufacturers Association.

NOTES AND NEWS

NOTES FROM THE CERAMIC SCHOOLS

Georgia School of Technology

The Fall Term of the Ceramic Department at Georgia School of Technology opened September 14 with 15 sophomores, 4 coöperative students, 4 juniors, one senior, and one graduate student. A. V. Henry, W. H. Vaughan, and Mrs. M. F. Hosmer constitute the personnel of the department.

During the past year, the laboratory has been additionally equipped with a surface combustion test kiln, frit furnace, fusion test furnace, jolly, throwing wheel, jar mill unit, and clay slip machinery.

Although Georgia now supplies 41% of all of the white firing clay in this country, many new deposits have been discovered and tested and a number of these are being developed on a commercial basis. All of the clay producers are now giving technical thought to improved methods of mining, refining, and blending.

The department is now coöperating with the State Geological Survey in a complete study of the clays in the State. It is expected that this work will require two years to complete, at the end of which time a new Geological Survey clay bulletin will be issued.

Iowa State College

In the four-year courses there are about 40 students, divided up into a freshman group of 18, a sophomore group of the same number, and with but 8 juniors and seniors. Part of the eight will graduate at the end of the Fall Quarter and some will be here an additional year. Indications are that there will be considerable growth from transfers from other departments.

Two women are enrolled for the four-year course. Both are interested in the idea of becoming research laboratory workers.

There have been no faculty changes.

The people in Iowa have awakened to the fact that they are supporting a Department of Ceramic Engineering and should send their sons to Ames to take work therein. Students know about the work and are interested enough to look into it. Iowa people now know that a ceramic engineer is not a china painter.

Ohio State University

The Ceramic Department of Ohio State University releases the following information based on class enrollments: Senior students, 31; junior students, 37; sophomore students, 50; freshmen students not recorded in departments, but estimated at 70; students in the Graduate School, 10; Fellowships, 3.

The teaching staff has been materially strengthened and is announced as follows: Arthur S. Watts, Professor and Chairman of Department; J. L. Carruthers, Assistant Professor; Geo. A. Bole, Research Professor; Sam'l. R. Scholes, Lecturer; Thos. M. Felton, Instructor; J. C. Lysatt, Technician.

This department has now the following fields of ceramic manufacture taught by men with practical experience in the industry: white ware, terra cotta, heavy wares, refractories, stoneware, metal enamels, and glass.

The University has installed more than one thousand dollars worth of new equipment in the Ceramic Department during the past summer and spent an equal amount on

rebuilding old equipment and increasing accommodations for students. Additional equipment is now being ordered and will be installed during the present year.

With the new equipment available and in coöperation with the Engineering Experiment Station of Ohio State University, many important researches are now being undertaken which will have great interest for the ceramic industry.

New York State School of Clay Working and Ceramics

Total registration of the school 162
Men 115
Women 47

Classes	Men	Women	Total
Senior	16	9	25
Junior	14	6	20
Sophomore	41	13	54
Freshman	43	19	62
Specials	1	0	1

New Members of Teaching Staff: Frank C. Westendick, Ohio State University, Professor of Ceramic Engineering; Clarence W. Merritt, Ohio State University, Assistant Professor of Ceramic Engineering.

North Carolina State College

The registration in the Department of Ceramic Engineering for the year 1926–27 is distributed in the following classes: Graduates 2, Seniors 8, Juniors 10, Sophomores 8, Freshmen 30, total 58.

The laboratory section of the Ceramics Building has been practically completed during the summer, and the various classes can now use the entire building.

This year marks the first in which the department has had a senior class and therefore the first in which a full gamut of ceramic courses have been taught.

The first meeting of the Student Branch of the AMERICAN CERAMIC SOCIETY was attended by 28 students and preparations were made for instructive programs for the year.

Pennsylvania State College

The registration in the Department of Ceramics this year is 22, consisting of 5 seniors, 3 juniors, 7 sophomores, and 7 freshmen. One senior, Harold R. Gingerich, graduated from this department in June and has been since employed by the Sandusky Cement Company, York, Pa.

There has been no change in the teaching staff of this department. The staff consists of J. B. Shaw, Head of the Department, and Walter R. Preische, Instructor.

University of Illinois

There are 91 students registered in this department this year, including graduate students. There has been no change in the teaching personnel. L. D. Fetterolf has been added to the staff and is assisting in research work.

University of Missouri

The present registration is six with only the Freshmen and Sophomore years included. There will, of course, be no graduates for two years, nor will there be any thesis work.

University of Washington

The ceramic engineering department of the University of Washington reports its registration for the fall quarter as follows:

Three graduate students majoring in ceramics including two U. S. Bureau of Mines fellowship holders. These are: 1. H. N. Baumann, Jr., who continues his work on the testing of various kilns of the Northwest and the calculation of their heat balances. 2. Vance Cartwright, a graduate of the Department of Chemical Engineering, University of Washington. His thesis work is on the various methods of dewatering clay suspensions with particular application to our eastern Washington kaolins. 3. Kenneth Johnson, graduate student and present chemist for the Northwest Experiment Station, U. S. Bureau of Mines.

Besides the above, 8 chemical engineering students are taking elective work in ceramic courses and 3 freshmen have entered the ceramic engineering department.

Reports of the kaolin and feldspar investigation which has been in progress for the past two years are being prepared. The investigation of the resistance of local brick and structural products to freezing is being continued, and likewise, the study of the scumming caused by local mortars in a series of 18, 16 sq. ft. brick panels will proceed through the winter.

University of Toronto

The number of students registering in the Department for the year 1926–27 cannot be given as the ceramic work is given as an option in the 3rd and 4th years. Two men will be taking work in ceramics this year. One is doing graduate work at local plants on the subject of fuel economy, while the other will take a ceramic subject for this thesis.

Robert J. Watson who took the ceramic option last year is now studying for his Doctor's degree at the University of Colorado. He will continue to specialize in ceramics and geology and will also be an instructor in the department of geology.

CHICAGO DISTRICT ENAMELER'S CLUB

The Chicago District Enameler's Club inaugurated their fall season with an excellent attendance and a fine paper on "Cast Iron Enameling" by Albert Vodika of the Aetna Porcelain Co. Mr. Vodika told how the dry process work was done 40 years ago, at that time Cornwall stone and sand being used as a base flux and as a consequence a much harder enamel resulted. Very often four sievings were necessary while today two are considered ample. Softer enamels, he said, give better looking ware, and make possible greater production. It is best to smelt the batch from one to three hours depending on the size of batch, and the batches should be stirred frequently with a non-sealing rod. Mr. Vodika also told of the defects in cast iron enamels, what caused them, and how they could be remedied.

Mr. Dvorak of the Crown Stove Co. gave a very interesting talk on synthetic cryolite. This material he found gives a more flexible enamel devoid of pinholes, a more velvety appearance, non-chipping, and of better gloss.

In a discussion of sign blues it was stated that 1½% of MnO_2 and ½% of nickel oxide assisted in preventing fading, red lead is detrimental, cryolite should be held as low as possible, burn color to 1700 or 1750°, and cut the borax down as much as possible. A few drops of boracic acid normal solution in sign spray cans will make the brushing easier.

Bruce Wagner has resigned as chairman of the club and J. A. DeCelle continues as chairman.

The next meeting will be held on October 26 when papers on "Sheet Steel Finish Coat and Opacifiers" will be read and a report will be made on sandblasting investigation carried on by Mr. DeCelle.

PROGRESS REPORT OF COÖPERATIVE SAGGER RESEARCH

The sagger research undertaken by the Ceramic Department, Georgia School of Technology, in coöperation with the Central of Georgia Railway has been practically completed. The investigation was undertaken as it was realized that the loss due to breakage and flaking of saggers has become an important item in plant operation. Also, the green and fired properties of certain of the Georgia kaolins indicated that they were well suited to sagger bodies.

More than 80 sagger mixes have been tested with regard to working character, green modulus of rupture, drying and firing shrinkage, fired porosity, fired modulus of rupture, flaking resistance, and expansion. Sixteen mixes in which Georgia clays formed a major portion, showed excellent working properties, high green strength, low shrinkage, good fired strength, medium porosity, medium or low expansion, and a resistance to thermal change varying from three to six times as great as the best of the commercial mixes examined.

About November 1, the mixes giving the best laboratory result, will be subjected to plant proving tests in three factories manufacturing whiteware products.

ORGANIZATION MEETING OF SUB-COMMITTEE ON SYMBOLS FOR HEAT, THERMODYNAMICS, AND THERMOMETRY[1]

The Sub-Committee of the A. E. S. C. Sectional Committee on Scientific and Engineering Symbols and Abbreviations held a meeting on April 5 at the office of H. N. Davis, Harvard University, Cambridge, Mass.

Those attending, and the organizations represented were as follows:

Name	Address	Representing
Robt. M. Anderson	Stevens Inst. Tech.	S. A. E.
H. N. Davis	Harvard Univ.	A. S. M. E.
A. E. Kennelly	Harvard Univ.	A. Acad. Sci. Inst. Radio Engrs. A. A. A. S.
Sanford A. Moss	Thomson Res. Lab. Gen. Elec. Co.	S. P. E. E.
E. F. Mueller	Bur. of Standards	Bur. of Standards
Ross C. Purdy	Columbus, Ohio	American Ceramic Society (Alternate for L. E. Barringer)
Geo. E. Seabury	Boston Edison Co. Boston, Mass.	N. E. L. A. (Alternate for C. H. Saunderson of the Boston Edison Co.)
R. B. Sosman	Geophysical Lab., Washington, D. C.	American Chem. Soc.
E. P. Warner	Mass. Inst. Tech.	(Alternate for S. A. E.)
J. F. Wing		Am. Gas. Ass'n.

[1]April 5, 1926.

P. W. Bridgman, Harvard University, appointed to represent the American Physical Society, and R. V. Kleinschmidt as alternate for Arthur D. Little, appointed to represent the American Institute of Chemical Engineers, were not notified in time to enable them to attend the meeting.

The Committee organized with Dr. Moss as Chairman, and Dr. Davis as Secretary, with Mr. Mueller as Secretary, pro tem.

The question of the propriety and desirability of having symbols in general handled by the Internation Electrotechnical Commission, was discussed informally. It was pointed out that International Electrical Symbols had already been promulgated. Dr. Kennelly spoke of the advantages of common standards, and suggested that the I. E. C. might extend its field. Dr. Moss stated that the A. S. M. E. would acquiesce in having the matter handled by the I. E. C.

Attention was called to the fact that symbols related to the field of this sub-committee had already been issued by the following organizations: the American Chemical Society, the American Society of Mechanical Engineers, the Physical Society of London, the International Scientific Union, and the International Union of Chemistry.

Dr. Sosman stated that the American Chemical Society would doubtless approve of having the subject handled by the I. E. C., but that he was not authorized to speak for the Society, his position being that of an observer.

As a result of the discussion, it was moved, seconded, and carried, "That it is the sense of this sub-committee that the International Standardization of Symbols in Heat, Thermodynamics, and Thermometry, falls within the scope of the I. E. C. and that that body should be requested to undertake such standardization."

The Committee then proceeded to consideration of symbols. The list prepared for the A. S. M. E. Power Test Codes was read, and it was then moved, seconded, and carried, that the Sub-Committee proceed with the preparation of a list of symbols.

Recess was taken at 1:00 P. M. for lunch, as guests of Prof. Kennelly. The Committee again met at 2:30 P. M. and prepared the list attached to these Minutes.

Adjourned at 3:00 P. M. Submitted by,

E. F. MUELLER, Sec'y. Pro Tem.

International Electrotechnical Commission

Advisory Committee on Symbols

A tentative list of symbols for heat and thermodynamics is given compiled by the Sub-Committee on Symbols for Heat, Thermodynamics, and Thermometry (A. E. S. C.)[1]

d = density (weight per unit volume) $= 1/v$
p = pressure, either absolute or gage (force per unit area)
v = specific volume, (volume per unit weight) $= 1/d$
c_p = specific heat at constant pressure
c_v = specific heat at constant volume
k or κ or γ = ratio of specific heats $= c_p/c_v$
Q = quantity of heat
W = quantity of work
J = mechanical equivalent of heat
A = heat equivalent of work $= 1/J$
A = area
k = thermal conductivity (heat units per unit time, per unit area, and per degree per unit length)

[1]These symbols are subject to revision.

C = thermal conductance (heat units per unit time per unit area, per degree) = k/x (x denotes length)
R = thermal resistance (degrees per heat unit per unit time per unit area)
U = thermal transmittance (heat units per unit time per unit area divided by degrees difference)
H = thermal transmission (heat units per unit time)
t = time
t or θ = temperature, °C or °F
T or Θ or θ = temperature, absolute, °C or °F
r or 1 = latent heat of vaporization of unit mass ($h_d - h_{liq}$)
s or ϕ or n = entropy of unit mass
u or i or e = internal or intrinsic energy of unit mass
h = heat content, total heat or enthalpy of unit mass $h = u + (A)pv$
Ψ or F or A = free energy or internal potential function = $u - Ts$
ζ or Z = Gibb's function or total potential function = $u + (A)pv - Ts = h - Ts$

Footnotes: Use letter subscripts only to denote special states, such as liquid or dry saturated vapor. A. S. M. E. test code practice is *l* or *liq.* for liquid and *d* for dry saturated vapor. (Thus h_{liq} and h_d are respectively, total heat for liquid and dry saturated vapor and similarly for v_{liq} and v_d.)

Use numerical subcripts only to denote states at designated points in an apparatus or process.

Preference has been given to lower case letters for specific quantities and to upper case letters for total quantities, except where practice was entirely to the contrary.

The same letter may have to be assigned to different quantities which usually do not occur in any one discussion.

The same quantity may have to have more than one symbol where agreement on a single symbol cannot be reached or to cover cases in which two quantities having the same symbol appear in one discussion. Where more than one symbol is given, the order indicates the order of preference. (It is to be hoped that further conference will reduce the number of options.)

The same symbol shall be used regardless of the system of units except where more than one system of units is used in a discussion.

The introduction of additional symbols for the quantities listed, should be avoided.

INDUSTRIAL RESEARCH LABORATORIES IN THE UNITED STATES

The continuing demand for a new edition of Bulletin No. 16 of the National Research Council which contains a list of Research Laboratories in Industrial Establishments of the United States indicates that this list apparently fills a certain need in the industrial world, and confronts us with the fact that the material assembled in 1921 is five years out of date and should be revised at this time.

It is undoubtedly true that since 1921 a large number of industrial concerns have established research laboratories. It is also probably true that the 1921 list does not contain a complete roster of the firms which had laboratories at that time. In order that the new list may be as complete as possible we are appealing to the readers of this journal who are connected with firms now maintaining research laboratories to send us a post-card giving the name and address of the firms with which they are connected. Questionnaires will then be sent to these firms.

The value of such a compilation lies first in its accuracy; second, in its completeness. The completeness of this compilation can be assured only by the coöperation of those in immediate touch with the various laboratories which should be included.

Please address your post-card to the Research Information Service, National Research Council, B & 21st Streets, Washington, D. C.

THE CERAMIC SOCIETY OF ENGLAND

The autumn meeting of the Refractory Materials Section of the Ceramic Society of England was held at Leeds in September under the chairmanship of Frank West, Chairman of the Section.

At the first session three technical papers were read and discussed. These were: "A Further Note on the Influence of Iron Oxide in Promoting the Inversion of Silica," by W. J. Rees; "Practical Results and Experience in the Drying and Burning of Refractory Materials," by F. West and J. W. Fagan; and "Refractory Linings for Cement Kilns," by G. Martin.

The second paper was an interesting description of the manufacturing processes adopted in the production of silica gas retorts at the Friden Works, Derbyshire, of the West's Gas Improvement Co., Ltd. Some interesting points were emphasized. It was stressed in the paper that the tendency in modern carbonization practice is towards higher and still higher temperatures, and therefore the manufacturer of refractories is being called upon to produce goods capable of sustaining temperatures far above those of 15 or 20 years ago. The kiln temperatures have had to go up in sympathy; at Friden they have been increased, in consequence to an average of 1500°C and over, for the higher grades of products, and it was claimed that the increasing use of scientific methods of operation and control, combined with better supervision, have resulted in an improvement of the quality of the products, as well as an increased efficiency of about 11% as compared with the figures of 9 years ago. Beehive kilns have been pulled down and replaced by semicontinuous chambers, and it was stated to be the view of the principals that although the tunnel kiln has not yet come into operation in silica works, they see no reason why this type of kiln should not ultimately be adopted, and when any future large extensions happen to be required at the Friden Works, this system will be seriously considered.

At the second session of the meeting three additional papers were read as follows: "The Influence of Foreign Matter on the Thermal Expansion and Transformation of Silica," by J. W. Cobb, H. S. Houldsworth, and J. F. L. Wood; "Refractories in the Gas Industry," by W. T. Gardner; and "A Note on Modern Clay Working Machinery as Used on the Continent," by H. M. Ridge. In the discussion which followed the reading of the paper bearing upon the gas industry a striking tribute was paid to the work of the Ceramic Society in rendering possible the production of a better type of refractory material, thereby leading to a longer life of gas retorts. G. M. Gill, a well-known gas engineer, said that it seemed to him, looking back over the last few years, that really good progress was being made by the silica brick makers, and, having had the advantage of visiting America, where similar material is exclusively used in coke ovens and retort settings, he was sure that Britain was in no way behindhand as regards the amount of research work that was being done, and the amount of assistance that was being given to the manufacturers and the users by our scientific people.

Dr. Mellor has established relations with Sir William Bragg, who had brought to the aid of the ceramic industry for the solution of some of its most fundamental problems, the results obtained in an entirely new field of inquiry, *viz.*, the X-ray. The possibilities which lie before the industry, therefore, in the realm of clay research are now almost illimitable.

NOTES FROM THE BUREAU OF MINES

Beneficiation of Low Grade Bauxite

An investigation having in view the devising of methods of beneficiating low grade bauxite so as to make deposits of such bauxite commercially available is being undertaken at the Southern Experiment Station of the Bureau of Mines, Birmingham-Tuscaloosa, Ala. A large number of low grade bauxite deposits occur in the states of Alabama, Georgia, Mississippi, and Tennessee, but only a small proportion of these deposits have been exploited so far, on account of the excessive quantities of impurities with which the bauxite is contaminated. The impurities are principally silica, iron, and titanium, and the main purpose of the investigation will be to find, if possible, some satisfactory way of eliminating these impurities.

Milling of Fluorspar Ores

The purpose of an investigation of the methods of milling fluorspar ore, being undertaken by the Bureau of Mines, Department of Commerce, is to determine the best methods and equipment to use, and to obtain data on the principles of ore dressing involved. In the fluorspar district of southern Illinois and Kentucky, the ores are largely fluorspar, silica, and calcite, and as these minerals do not differ greatly in specific gravity, their milling is a difficult problem. Work conducted by Bureau engineers in this district, extending over a year, has resulted in changes in nearly every mill in the district. The system of jigging unsized material in the Tri-State zinc district has been thoroughly studied, and an effort is being made to apply the information obtained to the milling of fluorspar. It was found that the practice of jigging unsized material, as applied to fluorspar ore and tailings, is not economical, and that good sizing before jigging is essential. The losses of fluorspar in the tailings were large; in some mills the tailings contained as much as 25% fluorspar. Radical changes in the construction of the jigs used were recommended by the Bureau of Mines engineers, and they assisted in installing changes in the jigs at four large mills that resulted in marked improvement in the work of the jigs. The most difficult problem, however, is to save the fluorspar in the fine material, less than 8 or 10-mesh in size, which in the past has been practically all lost in the tailings. After various experiments, the Bureau engineers with the coöperation of the mill operators developed a system of jigging, classification, tabling, and reclassification that treats successfully material as as fine as 100-mesh. As a result, one of the largest fluorspar companies in the district is engaged in remodeling its entire mill in accordance with recommendations of the Bureau metallurgists based on this work. The investigative work will be continued with a view to observing the benefits from such alterations, and to assist mill operators in further improving the methods.

NOTES FROM THE BUREAU OF STANDARDS[1]

Expansion of Gypsum

When calcined gypsum is mixed with water in the usual manner it becomes hard or sets. This setting process is usually accompanied by a change in volume which may be either an expansion or a contraction, but is usually the former. This property is important in making gypsum casts, as it causes the material to fill the crevices of the mold, resulting in clean-cut castings. Furthermore, expansion plays an important part in the adhesion of gypsum plasters to certain backings. It is well known that gypsum plaster having a minimum expansion on setting has a maximum adhesion to concrete. It is desirable to control the expansion in

[1]Bur. Stand., *Tech. News. Bull.*, No. 113, September, 1926.

such cases, and consequently a study of the factors affecting this property of calcined gypsum has recently been undertaken at the Bureau. The material to be measured is cast in specimens approximately 13 by 1 by 1 inches, and the linear changes on setting are followed by means of a microscopic comparator.

A series of specimens made from normally calcined gypsum mixed with varying amounts of water has been made and the resulting expansions measured. These results show that the expansion varies inversely with the amount of mixing water. Samples mixed with 47.5 % water gave an average linear expansion of 0.173 % while those mixed with 55.0 % water expanded 0.096 % with intermediate mixes in proportion. Further work in which the fineness of the gypsum, time of set, and method of calcination are varied is in progress.

Clay-Drying Investigation

In accordance with observations and conclusions based on data secured during the early part of the clay-drying investigation, the later and most successful tests have been made, following a schedule of temperature and relative humidity values and changes expressed by the following equations:

$$T = 35 + \frac{p^2}{110}$$

$$\text{Per cent } R.\,H. = 73 - \frac{p^2}{120}$$

where T = drier temperature in °C

$R.\,H.$ = relative humidity,

p = the already passed percentage of the whole contemplated drying period from start at room temperature to time of reading 110°C and 5 % $R.\,H.$

NOTE.—Varying from the above equations, T was preferably kept to 110°C as a maximum, while it was not found practicable to run R. H. below about 4 %.

In these drying tests, following the above-mentioned schedules of temperature and relative humidity and using bricks 2.5 by 4.5 by 10 in., it was found possible to dry some clays (a Dennison surface clay, a red-firing Peoria shale, a Canton shale, and a Veedersburg hard blue shale) in 4 to 7 hours without more than negligible drying injuries.

Other clays (including a surface clay, a Lewis run shale, and a Louisville blue shale) required 12 to 15 hours for satisfactory drying; while (1) a fire clay, required 20 hours; and (2) a "fire clay" and a Kittanning shale "fire clay," required 30 hours each. One "low-grade fire clay" was not successfully dried in 30 hours.

Both theoretical considerations and laboratory observations thus far made in the clay-drying investigation indicate that the clay properties tending to minimize drying injuries are:

1. A low drying shrinkage.

2. A high elastic rupture limit for the partially dried surface layer of the drying clay body. This differs from the so called "modulus of rupture" in that we are here concerned, not with the tensile strength of the material, but only with the amount of distortion or strain which the partially dried clay will stand before rupture.

Recent comparison tests on an easy drying clay and on a clay very difficult to dry satisfactorily show that, at the stage where 60 % of the water of plasticity has been evaporated, the ratio of per cent shrinkage to allowable safe strain in the easy drying clay is only about two-thirds of the value of that ratio as found for the difficult drying clay.

3. A high water conductivity, and, hence, relatively low water concentration and shrinkage gradients.

The Flotation of Enamels The work in studying the flotation of enamel slips by means of the capillary viscometer has been continued, and after trial of various sizes and lengths of capillaries and feed tubes a combination has been selected which seems satisfactory for testing slips covering the whole commercial range of consistency.

As the simplest way of showing the relative yield value and mobility for factory-control work rate of flow was plotted against the height of enamel slip in the apparatus.

That this method is capable of distinguishing between slips of different consistencies is shown by the following tabulated results, obtained in a factory:

Enamel and use	Relative yield value	Relative mobility
Ground coat for dipping small pieces	9.5	1.11
Ground coat for dipping large pieces	12.0	.96
White coat for "slushing" small pieces	18.6	.98
White coat for "slushing" large pieces	24.3	.81
White coat for spraying	32.0	.74
Blue cover enamel for spraying	14.5	.38
Blue cover enamel special adjusted	10.5	1.04

The blue spraying enamel had such low mobility that it was adjusted for test purposes. After adjustment the slip was more mobile and had much less tendency to clog the spray gun.

This instance illustrates the commercial value of the described test, for without it the nature of the defect in consistency would remain unknown. It could, therefore, be corrected only by cut and try methods.

Zinc Oxide and "Seeds" in Borosilicate Crown Glass Borosilicate crown glass is employed quite extensively for making the reflecting prisms used in optical instruments, such as range finders and periscopes, and it is also becoming popular for lenses and optical windows, and flats on which graduations or scales are ruled.

For some of these purposes the glass must have an index of refraction of approximately 1.517, and it must be absolutely free from even small bubbles or "seeds," as they are called. At times considerable difficulty is experienced in obtaining glass of the desired quality and in satisfactory quantities.

This kind of glass, free from seeds, has been made repeatedly in the Bureau's experimental glass plant, but the index of refraction is somewhat higher (1.520 to 1.523) than desired (1.517). In an effort to obtain a glass with the desired index of refraction the zinc oxide was eliminated from the batch, and although this gave the desired refractive index the glass was almost invariably "seedy." Although numerous changes were made in the temperature of the melting furnace, the length of time allowed for melting and fining, and the method of stirring, it was apparently impossible to made a "seedless" glass. As soon, however, as about 2% of zinc oxide was added to the batch the seeds disappeared, but the refractive index increased.

From this it seems that a reduction of the index of refraction by eliminating zinc oxide can only be made at the expense of the quality of the glass. The Bureau's next step will be to reduce the quantity of barium oxide to see if this change will give both the desired quality and optical constants.

The following table gives the index of refraction (N_d), dispersion (V), and the ratios between the percentages o fsilica, barium oxide, and zinc oxide (the alkalies and boric

oxide being practically constant) of four borosilicate crown glasses, the first of which contains no seeds, the others being practically useless because they were too "seedy."

Glass No.	Nd	V	SiO_2 : BaO : SnO
1	1.5230	63.5	1 : 0.040 : 0.040
2	1.5186	64.1	1 : .041 : .016
3	1.5169	64.6	1 : .040 : .004[1]
4	1.5176	64.7	1 : .037 : .011[1]

MULLITE REFRACTORIES TO BE DISCUSSED AT PITTSBURGH SECTION MEETING

At the next regular monthly meeting of the Pittsburgh Section, AMERICAN CERAMIC SOCIETY, a paper, "Mullite Refractories" will be given by T. F. Curtis, Director of Research, Vitrefax Company, Los Angeles, Calif. The paper will be open for discussion and promises to be most interesting.

The meeting will convene at 8:15 P.M., Wednesday, November 3, 1926, Fellows Room, Mellon Institute of Industrial Research, Pittsburgh, Pa. Mr. Curtis is recognized as an authority on refractories. All of those interested are cordially invited to attend.

BUREAU OF STANDARDS ANNIVERSARY

Twenty-five Years of Successful Scientific Research Work to be Celebrated

A celebration of the twenty-fifth anniversary of the Bureau of Standards of the Department of Commerce is just announced. On Saturday, December 4, next, the Bureau will keep Open House and a banquet will be given at which the many friends of the Bureau will meet the staff and reminiscences will be exchanged, the achievments of the quarter century will be reviewed, and the present and future work will be discussed. A group of distinguished guests will attend. The event is of interest to the world of science and as well to the industrial experts who have worked so closely in coöperation with the Bureau and in turn made application of its discoveries and developments in perfecting the measured control of processes. The opportunity to inspect the experimental research facilities of the Bureau will be welcomed by its many friends.

[1] The zinc oxide indicated was derived from the "cullet" used in starting the melt.

CALENDAR OF CONVENTIONS

AMERICAN CERAMIC SOCIETY		
Annual Meeting	Feb. 14–19, 1927	Detroit, Mich.
Chicago, St. Louis, and Ohio Sections	Nov. 19–20.	Urbana, Ill.
Pittsburgh Section	Nov. 3, 1926	Pittsburgh, Pa.
Amer. Assn. Advancement of Sci.	Dec. 27, 1926–Jan. 1, 1927	Philadelphia, Pa.
Amer. Engineering Council (General Meeting)	Jan., 1927	Washington, D. C.
Amer. Inst. Min. and Met. Engrs. (Annual Meeting)	Feb. 14–17, 1927	New York City
Amer. Mining Congress	Dec., 1926	Washington, D. C.
Amer. Soc. Mech. Engrs.	May 23–26, 1927	White Sulphur Springs, W. Va.
Assn. Sci. App. Makers	April, 1927	?
Glass Container Assn.	April or May, 1927	?
The Gypsum Industries	Dec. 1926	Chicago, Ill.
Hollow Building Tile Assn.	Feb. 1927	Chicago, Ill.
Natl. Academy of Sciences	Nov. 8–10, 1926	Philadelphia, Pa.
Natl. Assn. of Mfrs. of Pressed and Blown Glassware	March 8, 1927	Pittsburgh, Pa.
Natl. Exposition of Power and Mech. Eng.	Dec. 6–11, 1926	New York City
The Natural Gas Assn. of Amer.	May, 1927	Cincinnati, Ohio
Ohio Ceramic Industries Assn.	Nov. 12–13	Columbus, Ohio
Society of Glass Technology	Nov. 17, 1926	Leeds, England
(Eng.)	Dec. 15, 1926	London, England
Stained Glass Assn. of Amer.	June 27, 1927	St. Louis, Mo.
Taylor Society	Dec. 8–11, 1926	New York City

U. S. Rotary Enamel Smelting Furnaces Give

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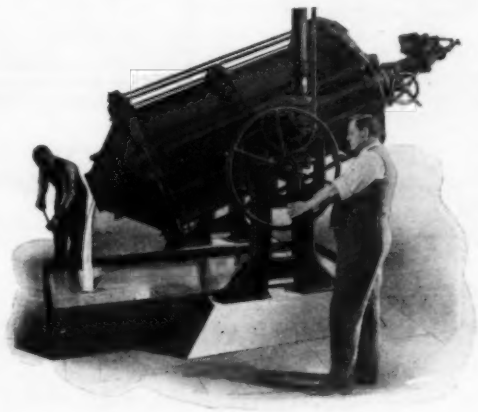

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Porcelain Enamel & Mfg. Company, Baltimore, Md.
Ingram-Richardson Mfg. Company, Frankfort, Ind.
Ingram-Richardson Mfg. Company, Beaver Falls, Pa.
Ingram-Richardson Corporation, Bayonne, N. J.
Grand Rapids Refrigerator Co., Grand Rapids, Mich.
Columbian Enameling & Stamping Co., Terre Haute, Ind.
Sheet Metal Products Company, Toronto, Canada.
Republic Metalware Company, Buffalo, N. Y.
Pacific Sanitary Mfg. Company, Richmond, California.
A. Weiskittel & Son Company, Baltimore, Md.
Malleable Iron Range Company, Beaver Dam, Wis.
Edison Electric Appliance Co., Inc., Chicago, Ill.
Welsh Tinplate & Metal Stpg. Co., Ltd., Llanelly, England.
Ernest Stevens, Limited, Cradley Heath, England.
Ward Leonard Electric Company, Mount Vernon, N. Y.
American Enameled Products Co., Chicago, Ill.
Michigan Porcelain Tile Works, Ionia, Michigan.
Stanley Insulating Company, Great Barrington, Mass.
Roesch Enamel Range Company, Belleville, Ill.
L. D. Caulk Company, Milford, Delaware.

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60 lb.	150 lb.	350 lb.	750 lb.	1200 lb.

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Area of Clay Belt 225 miles long and from 20 to 50 miles in width.
Many of the deposits can be worked with little or no industrial haulage.

GEORGIA KAOLIN AND REFRACTORY CLAY

In fifteen counties in the Coastal Plain, all contiguous to the Central of Georgia Railway, there are abundant deposits of clays to meet the requirements of any particular industry. Many of these properties have been prospected.

The cost of mining is exceptionally small—because the overburden is comparatively light and the thickness of the clays permits the use of steam shovels.

These clays are now being used largely in the manufacture of paper, cloth, textile, oil cloth, paint, rubber, wall plaster, pottery, floor and wall tile, porcelain, sanitary ware.

Deposits range from ten to forty feet in thickness and extend over an area of two hundred and twenty-five miles long and from twenty to fifty miles wide constituting the largest clay belt in Eastern United States.

Many choice properties are still awaiting development. To those interested, the Central of Georgia Railway will gladly lend every assistance in the selection of suitable locations.

The Central of Georgia Railway coöperating with the U. S. Bureau of Mines has conducted laboratory and plant tests to determine the commercial values. Literature describing the deposits and reports giving the results of research work are available to those interested.

WRITE FOR THESE BULLETINS:

Directory of Commercial Minerals in Georgia and Alabama along Central of Georgia Railway.
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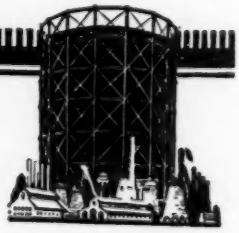

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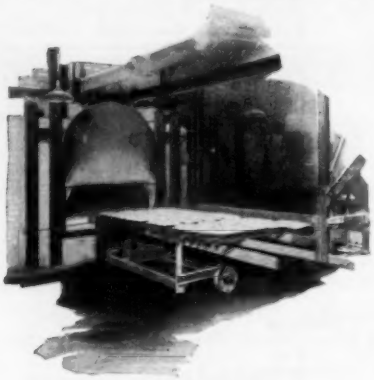

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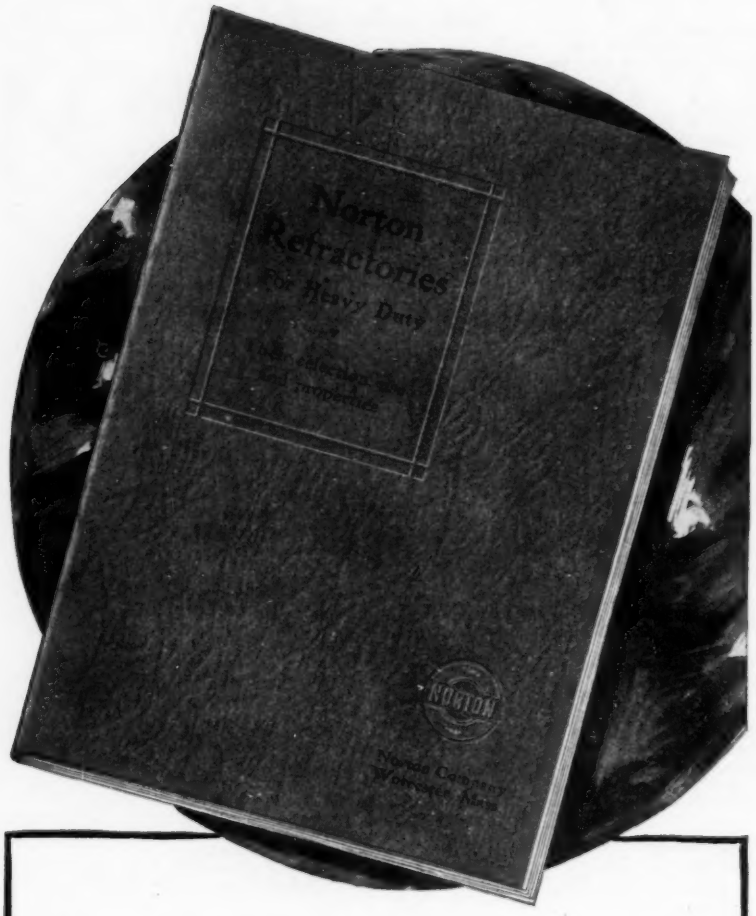

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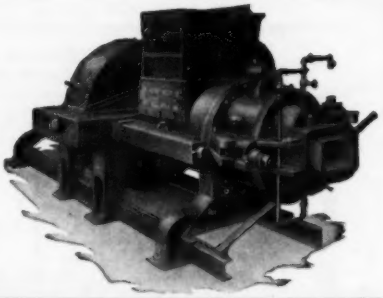

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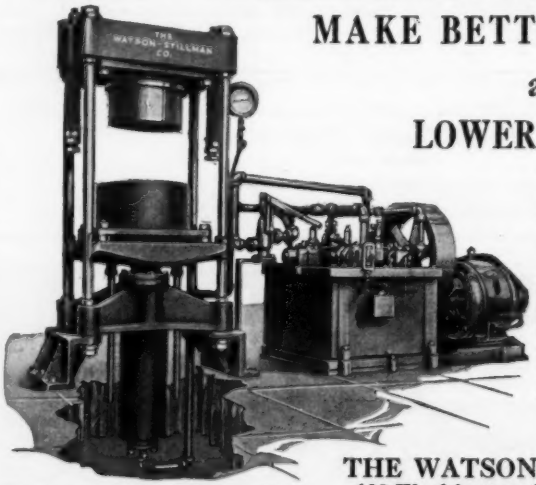

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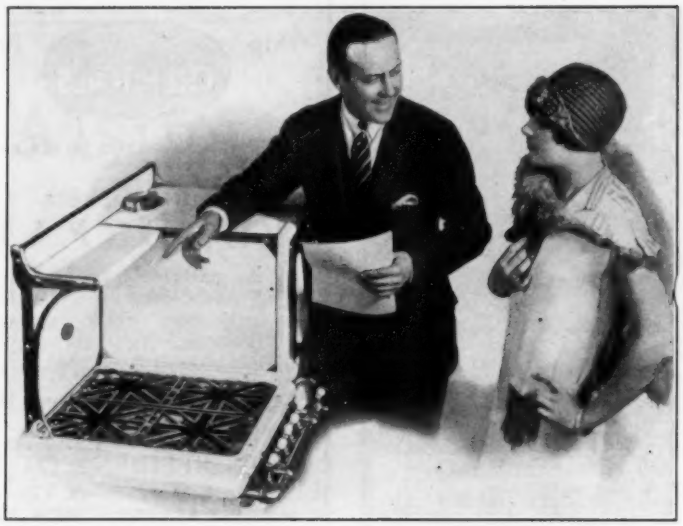

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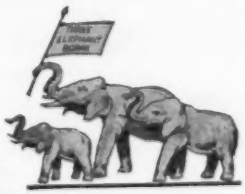

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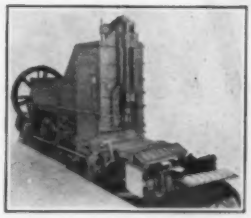

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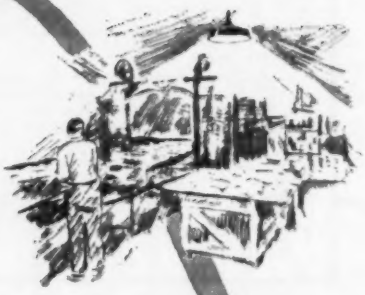

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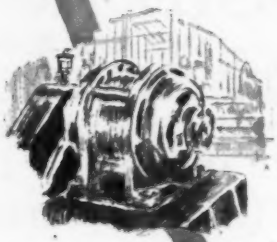

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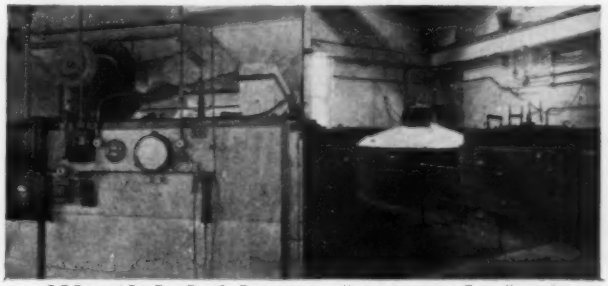

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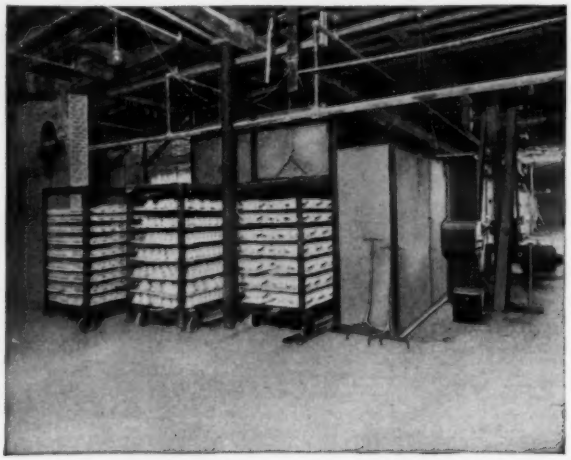

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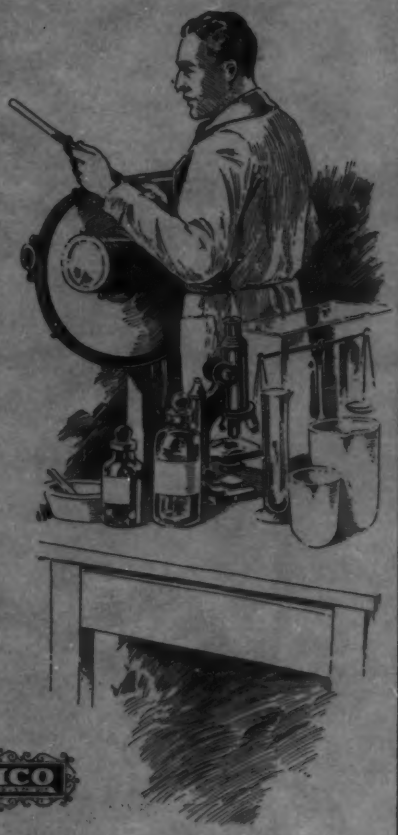

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